BLAZING FAST SOLID STATE

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APC+

YOUR EXPERT

May 2017
Issue 441

NEW AMD AM4 MOTHERBOARDS ROUNDED-UP

WE COMPARE SEVEN BRAND-NEW BOARDS FROM THE MAJOR VENDORS — AND FIND SOME SURPRISINGLY AFFORDABLE & FULL FEATURED OPTIONS

AMD HAS RISEN

AFTER MORE THAN HALF A DECADE IN THE WILDERNESS, AMD HAS RETURNED WITH NEW CPUS THAT AIM TO TACKLE INTEL'S BEST. WE REVEAL HOW IT DID IT... AND INVESTIGATE WHETHER RYZEN IS REALLY READY FOR PRIME TIME

HOW TO BUILD A KILLER RYZEN PC

WE GO THE WHOLE HOG AND CELEBRATE AMD'S REVIVAL WITH A SYSTEM THAT CAN TAKE ANYTHING YOU CAN DISH OUT – AND WE MEAN ANYTHING!

CURVED DISPLAYS COMPARED

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- IMPROVE AUDIO ON YOUR ANDROID SMARTPHONE OR TABLET
- PLAY DOOM ON A RASPBERRY PI
- LEARN TO CODE YOUR OWN GAMES IN PYTHON

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Distributed in Australia and NZ by Network Services.

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FIPP

Give yourself an IoT security audit

APC's editor explains what you can do to prevent your Internet of Things gear from being unwitting contributors to hack attacks.

To anyone who keeps even half an eye on tech news, the fact that poorly secured Internet of Things (IoT) devices have powered several major internet outages over the last year will be no surprise.

Recently, however, someone's seemingly taken the problem into their own hands, waging a war on Internet of Things devices by destroying them. A new piece of malware that specifically targets IoT devices has been named BrickerBot and, as the name suggests, it's modus operandi is to deliberately brick any unsecured IoT devices it can find by corrupting their internal storage.

So with the prospect of your IoT gear turning into expensive paperweights, now's a good time to audit any devices you own. IoT gear can take many forms – basically, any product that connects to the internet that's not your smartphone, tablet or PC falls under the banner, including:

- Networked security cameras
- Home-automation gear
- Smart lighting
- Wireless routers
- Wi-Fi extenders
- Networked media players

There's a range of factors that can make IoT gear insecure, from having certain settings deep within their firmware turned on that shouldn't be, to using the default logins for open-source software they use and more. So here's what we recommend you do to secure devices – note that most of these will require you to log into a device's web interface or via a dedicated app:

- Change the default administrator login and password credentials
- Regularly update your devices to the latest firmware – set a calendar reminder to do so every 3 months
- Alternatively, if a device supports it, set up automatic (unattended) firmware updates that don't require any intervention on your behalf – that way, you don't even need to think about it
- If you don't use or access your devices while you're away from home (or work), turn off remote access

It's worth noting that bigger, name-brand vendors are often better at issuing security updates than smaller, lesser-known companies, so if you have no-name IoT gear, it may take some digging to find security updates. If you're unsure whether a device is secure or not, we'd unplug it until you can confirm – it may seem innocuous, but one insecure IoT gadget could potentially be a backdoor into your entire network. ■

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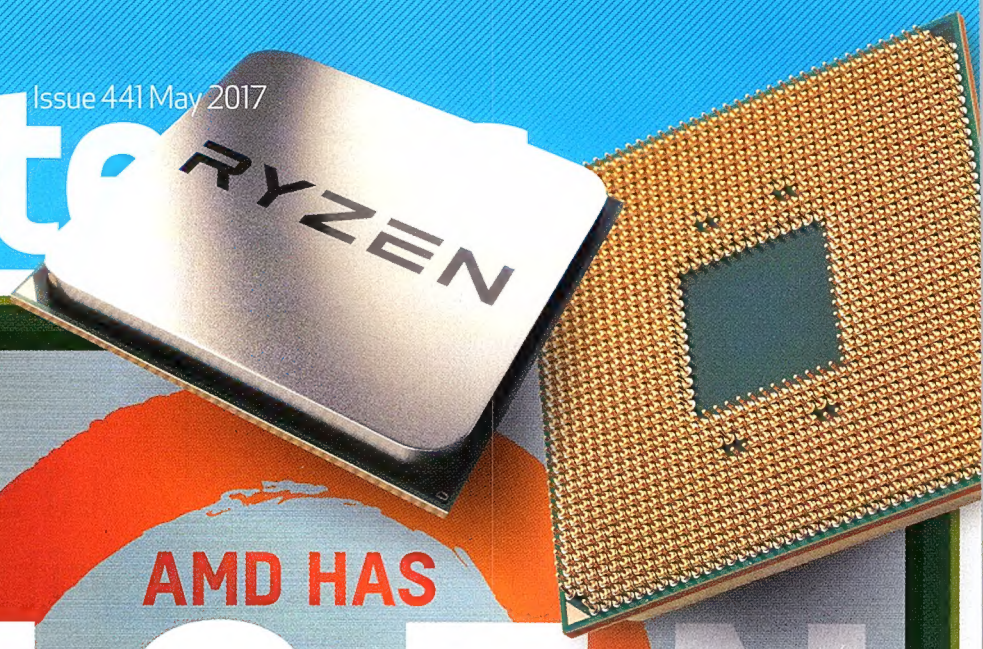
Issue 441 May 2017



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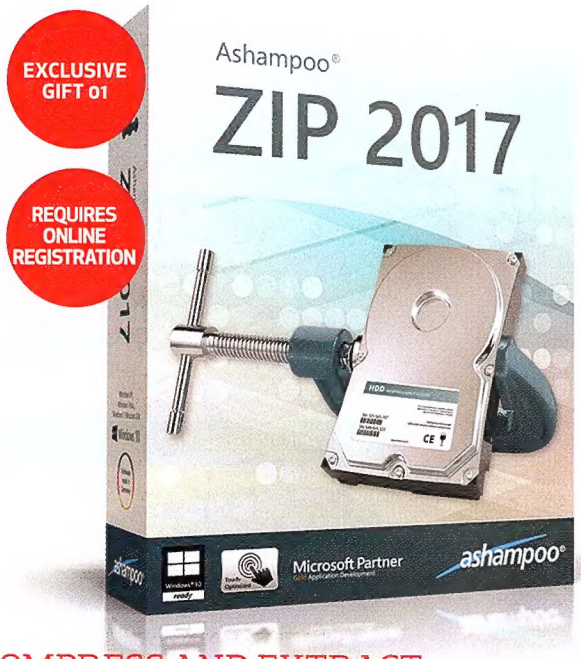

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Control over 60 archive formats with Ashampoo Zip 2017

FULL VERSION REQUIRES ONLINE REGISTRATION.

The new Ashampoo Zip 2017 is a compact and powerful file compression application that creates and extracts archives in over 60 formats with ease. The integrated Zip engine is the fastest on the market with full multicore support and processes even huge files quickly. Well-structured and intuitive, the program helps beginners achieve great results instantly. Aside from traditional use cases like opening and creating standard archives, Ashampoo Zip 2017 can also create self-extracting files and repair corrupted archives.

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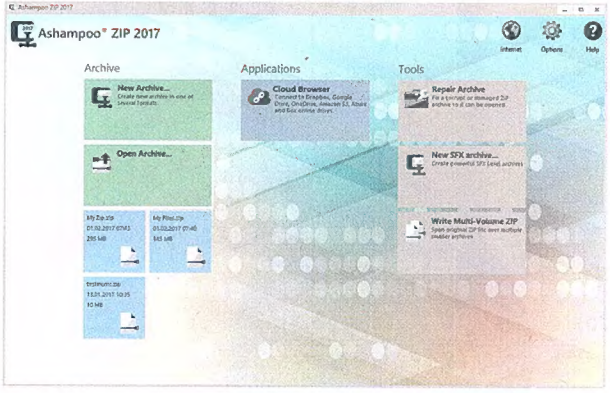

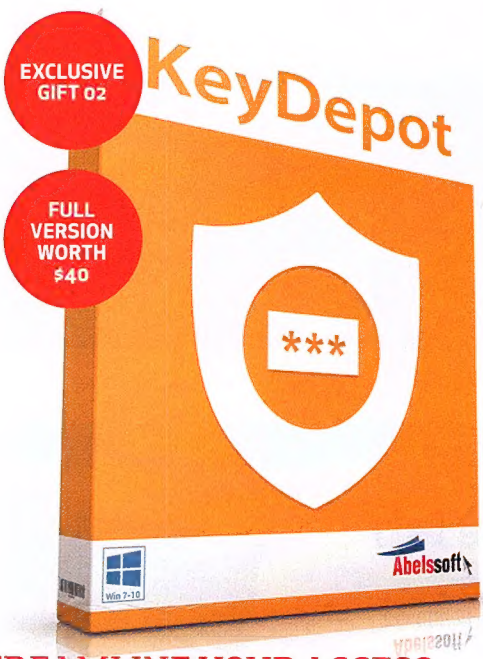

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» NEED TO KNOW

Streaming high

QANTAS DEAL MAKES IN-FLIGHT AUDIO AND VIDEO STREAMING AVAILABLE VIA FREE WI-FI.

Qantas has partnered with big-name streaming services including Netflix, Foxtel and Spotify to provide domestic customers on the Flying Kangaroo a wider variety of onboard entertainment, and from mid-April, Stan will join the bandwagon, too. To make the streaming seamless, the national flyer is equipping its first fleet of 80 aircraft, including Boeing 737s and Airbus A330s, with NBN-supplied Wi-Fi that boasts of speeds of up to 12Mbps and will be available free of charge on domestic flights. **SS**

Bitcoin and other cryptocurrencies now legal tender in Japan

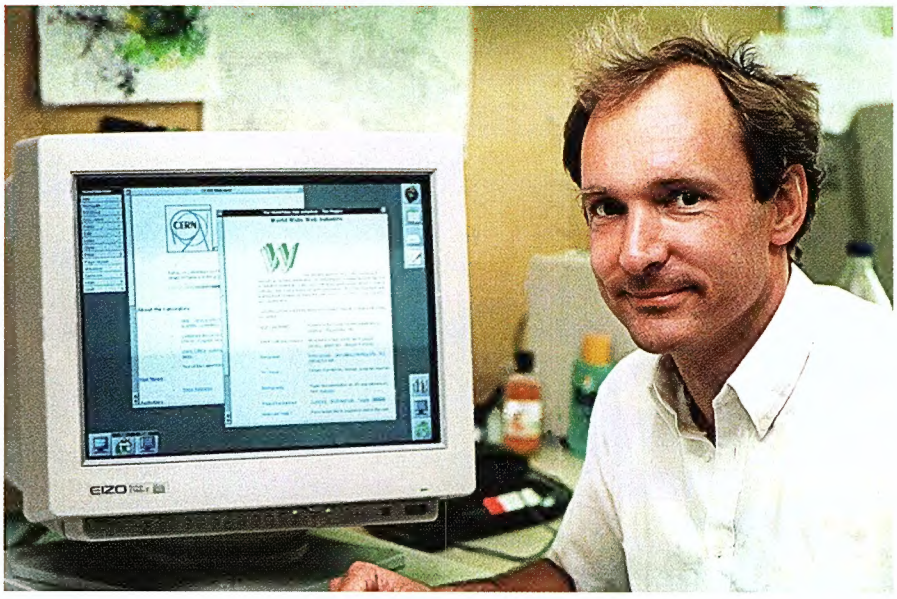
CASH, CARD... OR SOMETHING COMPLETELY UNTRACEABLE?

New legislation passed in March 2017 now allows digital currencies to be used as legal tender in Japan, meaning that cryptocurrencies such as Bitcoin and Ripple will be government-regulated and, hence, subjected to the same laws as regular money. The decision is the culmination of a lengthy process that started when one of the largest cryptocurrency exchange services lost around $650 million to hackers. A framework is currently being developed to help understand digital currencies in the Japanese accounting sector. **HD**

Wikileaks' dump exposes CIA hacking practises

WHILE MANY OF THE SECURITY FLAWS ARE ALREADY FIXED, A LARGE NUMBER REMAIN OPEN.

In the most recent WikiLeaks data dump titled Vault 7 'Year Zero', the whistle-blowing organisation has leaked 8,761 US-government documents that expose a plethora of CIA hacking practises. In particular, the documents expose the agency's penchant for exploiting Android and iOS devices via 'zero-day' exploits or undetected loopholes, as well as turning 'smart' TVs into audio-visual recording devices, although we don't know if these practises are in use. **HD**



Web's inventor weighs in on its future

Berners-Lee says the internet needs an overhaul.

On the occasion of the internet's 28th birthday, Sir Tim Berners-Lee published an open letter on the World Wide Web Foundation website lamenting about the "three new trends" affecting the internet – our loss of control over sharing of personal data, fake news or 'misinformation', and political advertising.

On the 4th of April, Berners-Lee received the prestigious Turing Award and has made it clear that he isn't done with the internet yet. He's begun working with the Decentralized Information Group at MIT to change the current state of the web for a more private online future.

Sir Tim hopes to achieve that via an open-source project called Solid, which will overhaul the way the internet works – standardising how data is stored and accessed, with specific information being stored on specific servers, allowing for better online privacy.

Berners-Lee hopes that people will join him in his fight to make the web a better place, saying, "It has taken all of us to build the web we have, and now it is up to all of us to build the web we want – for everyone." **Sharmishta Sarkar**

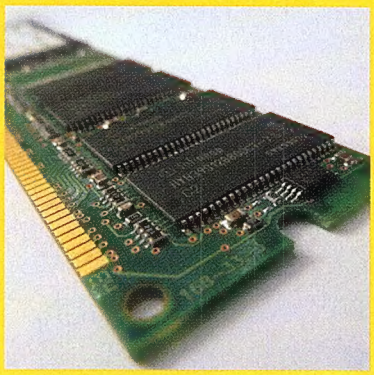
Proposed US immigration law would require Aussies to provide social media passwords at border

ALONG WITH OTHER PERSONAL INFORMATION.

After having attempted to impose a travel ban on certain predominantly Muslim nations, US President Donald Trump's administration is reportedly now considering extending what it has dubbed "extreme vetting" to a much wider group of visitors — including those that America counts as long-term allies, such as Australia. While not as severe as a total travel ban, the practices reportedly under consideration would allow US border security to forcibly obtain phone contacts, financial data, and social media passwords and handles from Australians flying to the US. Individuals who refuse the requests could find themselves refused entry into the country.

Although Trump's previous travel bans were overturned by the courts, these new practises could include countries participating in the US visa waiver programme, which includes the UK, Australia, Japan, France and over 30 other nations.

In regards to the proposal, senior counselor to Homeland Security secretary Gene Hamilton has stated that, "If there is any doubt about a person's intentions coming to the United States, they should have to overcome — really and truly prove to our satisfaction — that they are coming for legitimate reasons." **Harry Domanski**



Final DDR5 specs double speed and performance of DDR4

NEW MEMORY TO BE RELEASED IN 2018.

The JEDEC Solid State Technology Association has announced that the new standard for computer memory, DDR5, will be available in June 2018 and should double the speed and performance capabilities of existing DDR4 RAM. The technology has been under development since late 2015 and, while technically available from mid-2018, may not reach widespread consumer use for a further year or two. **HD**

Gaming peripheral maker Mad Catz to shut down

HAVING USED UP ALL NINE LIVES.

Mad Catz, the company best known for its gaming hardware and accessories has had financial troubles over the past several months, with the CEO resigning in 2016 and employees being laid off. Mad Catz has filed for Chapter 7 bankruptcy after it was delisted from the New York Stock Exchange over its abysmally low trading price — it's the kind of bankruptcy from which companies don't readily recover. **SS**

Oculus head honcho Palmer Luckey out of Facebook

THE RIFT WIDENS.

The college dropout who pretty much kickstarted the VR trend is leaving Facebook, after selling his company to the social media giant in 2014. It was revealed last year that Palmer Luckey funded pro-Trump memes, then went underground, only to be seen once in a courtroom in Dallas, Texas. No comments have been made regarding the cause of his departure, but speculations are rife as to how the embattled 24-year-old will bounce back. **SS**

ACCC suing Apple over iPhone repair policy

'Error 53' could prove costly for Cupertino.

The Australian consumer watchdog is taking Apple to court for its uncompromising repair and warranty policy, specifically regarding the Error 53 bug that plagued Apple users last year. The ACCC is alleging that the tech giant made "false, misleading, or deceptive representations on consumer guarantees" that are protected under Australian Consumer Law.

The legal action is the result of an investigation conducted by the ACCC after numerous iPhones and iPads generated an 'Error 53' on being disabled while updating to iOS 9 in 2015, which had a feature that could detect if a device had undergone third-party repairs. Apple refused to help the affected customers on the premise that they hadn't utilised the company's services to fix their faulty device.

"Denying a consumer their consumer guarantee rights simply because they had chosen a third party repairer not only impacts those consumers, but can dissuade other customers from making informed choices about their repair options, including where they may be offered at lower cost than the manufacturer," said Rod Sims, chairman of the ACCC. **Sharmishta Sarkar**

American internet privacy laws rolled back

US ISP'S CAN NOW LEGALLY SELL USER DATA.

Towards the end of Obama's presidency, the Federal Communications Commission (FCC) issued laws that would essentially act to prevent US internet service providers (ISPs) from selling their customers' data without their explicit permission. The privacy rules were set to be put into effect some time after December 2017, but have now been eliminated as a vote was passed in US Senate and House of Representatives to repeal the rules and has now been signed by President Trump. As for the direct consequence, nothing has technically changed in the active law surrounding ISPs as the FCC's rules never came into effect, but there has been public outcry over the repeal, with many critics viewing it as a step back for digital privacy in the country.

In 2015, Australia introduced data retention laws that requires Australian ISPs to retain data about their customers' internet and phone service usage. This metadata is currently kept for a period of two years, can only be used in serious criminal or national security investigations, and is only accessible by law enforcement and national security agencies. This ostensibly removes the chance of your data being sold, however, that's not beyond the realm of possibility. **Harry Domanski**

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» HARRY DOMANSKI LOOKS AT THE NUMBERS DRIVING THE BIG TECH NEWS

60%

AUSTRALIAN GROWTH OF WINDOWS TABLET SALES IN THE SECOND HALF OF 2016.

Although the Windows phone is more or less dead, Microsoft is doing quite well in the tablet market, with a 60% increase in Australian sales in the second half of 2016 — a period in which both Android and Apple tablets sales declined. This boost could have a lot to do with the growing popularity of 2-in-1 devices, like Microsoft's own Surface line, and its alignment with professionals and creatives, rather than casual users.

8.4 billion

NUMBER OF CONNECTED INTERNET OF THINGS (IOT) DEVICES FORECAST TO BE IN USE IN 2017.

A study from world-leading IT research company Gartner Inc. has projected a 31% increase in the amount of internet-connected "things" in 2017 from the previous year, with 8.4 billion devices expected to be in use worldwide. Not only that, but Gartner anticipates this number to exceed the 20 billion mark by 2020. With the rise of Amazon's ever-present Alexa and Google's Home, alongside the addition of 'smart' capabilities to mundanities such as hairbrushes and toasters, this figure is perhaps more damning than surprising.

117GB

HOW MUCH DATA THE AVERAGE AUSSIE HOUSEHOLD DOWNLOADS EACH MONTH.

Recent figures from the Australian Bureau of Statistics show that the average Australian home downloaded 117GB of data per month in 2016, which marks a 41% increase from the previous year. Although data consumption has been exponentially rising, the normalisation and household integration of streaming services such as Netflix is likely to account for recent spikes in usage.

#2

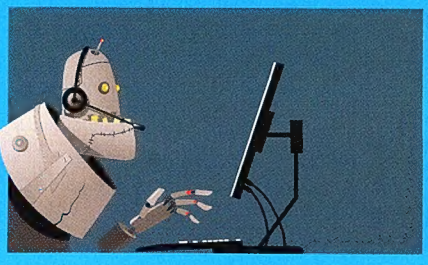
WINDOWS LOSES ITS LONG-HELD POSITION AS THE MOST POPULAR OS FOR BROWSING THE WEB.

With the widespread increase in popularity of Android-powered smart devices, as well as a global trend towards 'mobile first' web browsing, it may be unsurprising to learn that more people now browse the web from an Android-based device than from a Windows desktop, laptop or tablet. With a 0.02% lead at present, Android holds the lion's share of the web-browsing market with 37.93% of all web activity, with Windows, iOS and macOS following, respectively.

15%

AMOUNT OF ACTIVE TWITTER ACCOUNTS THAT ARE ACTUALLY BOTS.

Research out of Southern California and Indiana Universities suggests that up to 15% of all active Twitter accounts are, in fact, bots. This percentage would equate to nearly 48 million robotic accounts, which are involved in everything from promoting propaganda to issuing alerts for natural disasters or, in some cases, even just lying dormant. The research made use of over a thousand identifying traits to weed out the bots, including elements like sentiment, friends and time between tweets.



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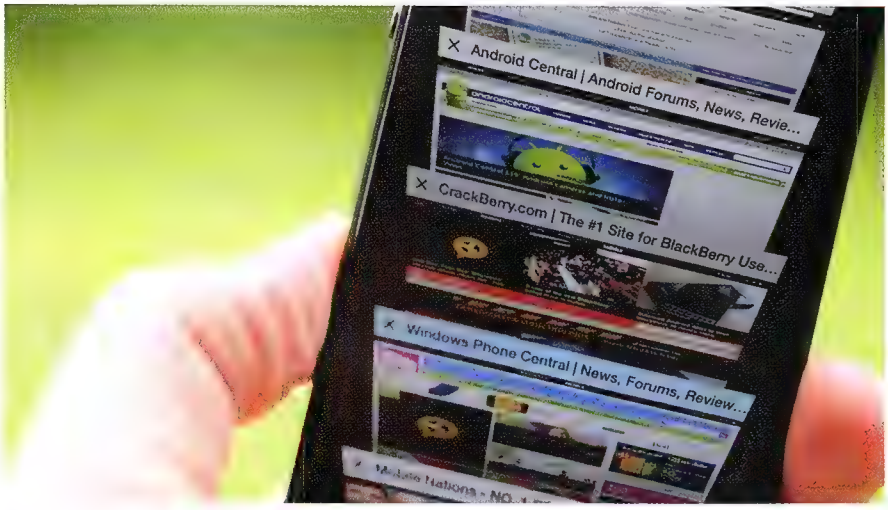
» CARMEL SEALEY WADES INTO A CURRENT NEWS TOPIC TO TAKE A CLOSER LOOK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Ransomware on the rise

The malware looking to make a few bucks.

Ransomware, a type of malicious software or designed to extort the victim, may have only started making headlines recently, but it's been around for over a decade.

These 'cryptoviral' attacks lock down the victim's computer or mobile device and demand payment in exchange for decrypting the data. In this sort of attack, infected files themselves are often replaced with the ransom letter, giving instructions as to how the victim can unlock their files. Lockscreen ransomware is immediately obvious to the victim, as the screen is taken over by a single window that blocks the owner from using their device until the stated demands have been met. Ransomware sometimes threatens to upload the victim's data to the internet in what is referred to as a 'cryptoviral leakware attack'. Attacks can also target your computer's Master Boot Record (MBR), disrupting its startup booting sequence.

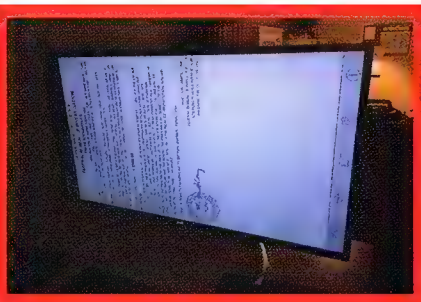
In most instances, once the ransom has been paid, the author of the malware follows through and releases the hostage device. However, we cannot stress enough the importance of backups, as this turns any malware attack from a potential disaster into a mere inconvenience on your part.

A third of ransomware victims suffer data loss

According to a study carried out by backup and "disaster recovery" software company Acronis, a staggering one in three victims of ransomware (more than 34%, to be more precise) suffer some kind of data loss. The study involved people from Australia, Germany, France, the US, the UK and Japan, and revealed that there was a "serious disparity" between how valuable victims considered their data and what they were actually doing to protect it. The CMO of Acronis stated that, "Backup still remains the most effective vaccine against data loss" and we agree with him.

Even the iPhone isn't immune

Mobile devices are not safe either, and while you may think this is just an Android problem, not so. iPhone users recently suffered a scare by what has been revealed as fake ransomware. Instead of locking the device, it ran through JavaScript and locked down the device's web browser, demanding the victims send the code for a £100 iTunes gift card via text. According to security firm Lookout, the ransomware doesn't encrypt any data, it just pretends to, and scares the user into carrying out its demands. Apparently clearing the browser cache is enough to get rid of it. Apple has released a software update in an effort to prevent it from happening again.



Your TV can get it

Smart TVs can be very useful until they also fall victim to ransomware, as Darren Cauthon — a software engineer — unfortunately discovered late December last year. Infected with Cyber.Police ransomware, which demanded he pay US$500 to unlock his Android-powered TV, Cauthon attempted to factory reset the TV to solve the issue. However, the solution provided online didn't work, so he was forced to visit a service centre. While it's unknown (to us, at least) whether the ransomware infected the TV through official or more dodgy avenues, the fact remains, Android powered devices, whether they're phones, tablets, watches or TVs, are equally susceptible to malware.

The No More Ransom Project offers free help

WWW.NOMORERANSOM.ORG

This is an invaluable resource when it comes to educating yourself, identifying and reporting ransomware. Providing thoroughly useful information on the types of ransomware currently out there, how you could become infected, what you should do if you fall victim to an attack, how it all works and how to protect yourself (Back up! Back up! Back up!), the site is a great initiative that is well worth investigating. Plus, they also offer free ransomware decryption tools that might just get you out of trouble!

technotes

» GEAR WE WANT

CROSS PEERLESS TRACKR

US$250 (AU AVAILABILITY TBD) | WWW.CROSS.COM

If you're into fancy pens but also have a penchant for losing anything smaller than your face, the Cross Peerless TrackR could be the ultimate Cross(™)roads of luxury and locatability. Cross is a distinguished designer of high-end writing instruments, from pens built from dismantled AK-47 assault rifles out of Africa to 23-karat gold fountain pens. The Peerless TrackR features integrated Bluetooth connectivity so you can see your wonderful pen's last known location via an app, or get a notification when you go more than 30m away from your beloved inker. The locater works both ways as well, meaning you can find your phone with a tap of the pen's button. **HD**

ELGATO STREAM DECK

$199 | WWW.ELGATO.COM

Elgato's Stream Deck is aimed at the live web-video broadcasters who want that extra taste of professionalism and convenience with their streams. The Deck itself is essentially a panel of 15 buttons, each featuring its own LCD screen, but its abilities lie in its customisability and depth. Connecting via USB, and communicating with host software, the Stream Deck enables you to assign each of its keys to any of 210 actions, whether that's launching websites, playing GIFs, scrolling Twitter handles, muting audio, or saving a replay. The interface is simple as well, allowing you to customise each of the buttons' displays for easy recognition when in the heat of the moment. **HD**

TRAEGER TIMBERLINE 1300 GRILL

FROM US$1,699 (AU AVAILABILITY TBD)
WWW.TRAEGERGRILLS.COM

Traeger is an American company that does premium barbecues and grills, and its Timberline range packs some top-notch features like modular shelving and 'Smoke Science' technology. But the most impressive addition is something Traeger is calling 'WiFire' — your grill connects to your home Wi-Fi network so you can control temperature, set timers and browse the Traeger community for pro tips and recipes, all from an app on your phone. You can also create custom 'cook cycles', enabling you to plan out a series of temperatures and cooking durations that you can perfect over time, for (hopefully) consistently delicious meals. **HD**

PHILIPS HUE E14 CANDLE

MEETHUE.COM | $29.95 (WHITE AMBIANCE), $49.95 (WHITE AND COLOR AMBIANCE)

Philips' range of Hue bulbs is set to gain two new members later in 2017. The forthcoming models will feature the E14 thread size, which will enable you to use them in lamps and other things with that fitting. The White Ambiance bulb is adjustable through warm to cool white light, and Philips says it can help you to wake up and go to sleep naturally. Meanwhile, the White and Color Ambiance bulb can be set to one of 16 million colors. The Hue Bridge that enables Hue products to work with Apple's HomeKit system consequently means you'll no longer have to fumble for your bedside lamp's switch – just talk to Siri.

PLUME LABS FLOW

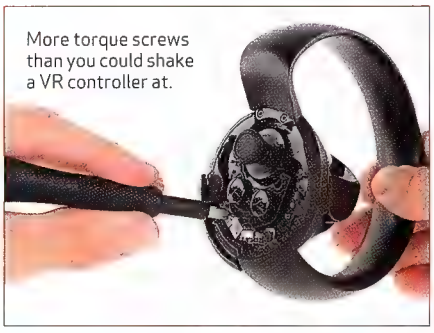
PLUMELABS.COM | $TBC

It looks a little like a speaker, but Flow is actually a smart air quality tracker. It's not just for inspecting air quality indoors, either – it's a small device you can hold in your hand, or tie to your bag so it can do its job while you're outdoors. Flow can sense particulate matter and dust, exhaust fumes, ozone, household chemicals, temperature and humidity. The idea is that every Flow user feeds data into the same system, building a more thorough picture of where air is good or bad, and highlighting the best places and routes around your city.

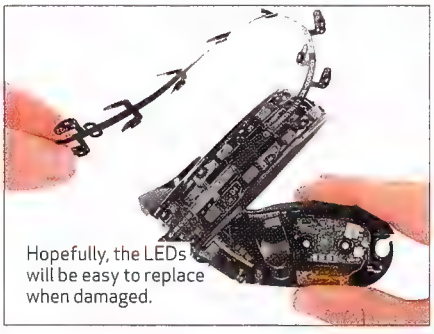
TAG HEUER CONNECTED MODULAR 45

TAGHEUER.COM | FROM $1,550

Are you put off by the rectangular screen on the Apple Watch? Apple's choice doesn't mean you can't get a smartwatch with a circular face, though you'll need to be happy to mix your Apple gear with another kind – in this case, the Android Wear system that powers this gorgeous-looking luxury device from Tag Heuer. This is the first Swiss-made smartwatch, and it features an AMOLED display. It's nice to have options for personal devices, especially when they look as nice as this one. ■



More torque screws than you could shake a VR controller at.



Hopefully, the LEDs will be easy to replace when damaged.

Oculus Touch

We tear apart Oculus' late-arriving motion controls.

Oculus finally catches up with the Vive with the release of its ultra-responsive Oculus Touch controllers. Requiring a second IR camera and featuring a whole mess of tactile and capacitive input options, these controllers are bound to be chock-full of IR LEDs and tons of exciting tech.

MAJOR TECH SPECS

- An additional Oculus Sensor
- A Rockband adapter
- Two IR-emitting Touch controllers, with finger tracking and a mess of buttons

KEY FINDINGS

- Using our fancy IR-viewing tech, we get an Oculus Sensor's-eye view of the Touch controllers. While the twin black plastic halos are featureless to the naked eye, our camera sees the double rings of infrared LEDs residing beneath. The LEDs, like those present in the headset, are arranged in distinct patterns, allowing the Oculus Sensor to pick out the headset and two controllers, and determine their position and orientation. Also, thanks to the not-quite-round shape of each controller, the sensor ought to be able to tell left from right — even after you've crossed your arms while playing *Disappointed Parent Simulator 2016*.
- The battery panel is secured by a pretty hefty magnet, and packs a rubber bumper to keep the battery itself nicely in place. Said battery is a non-rechargeable but perfectly standard AA type, which you can replace with a rechargeable at the first opportunity. Better this than a glued-in battery!
- There are some hidden screws, but even after removing them, we're not getting anywhere. Looking around for another point of attack, we decide the top is as good a place as any. Smelling glue, we turn up the heat! Prying up the control surface reveals gobs of glue, and the cause of our troubles: another hidden screw.
- Uncovered, the single-cable LED array peels off fairly easily after being disconnected. All 22 IR LEDs are conveniently labeled, and there's even a barcode. Cross your fingers for Oculus-provided replacement parts! Digging deeper into the handheld's handle, we find a cute little power distribution board — that we can't remove without a soldering iron.
- **Repairability Score:** 5 out of 10 (10 is easiest to repair). Battery replacements are quick and easy, with a magnetic cover being the only barrier to entry. There are only T5 and T6 Torx screws in the Touch controllers, making screwdriver selection seamless. Accessing the Touch controller internals requires fighting through a layer of adhesive. The joystick, button bases and battery connections are soldered to a board and require soldering knowledge to repair. Navigating through the tabs, adhesive and hidden screws is not intuitive, and could result in damage during disassembly. ■

About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit **www.ifixit.com**

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technotes

» EPINIONS

NBN CONNECTION, ADSL SPEEDS

After reading Carl Francis 'NBN upgrade a mixed bag' letter in last month's issue (see *APC* 440, page 16), I thought I'd share my experience when switching NBN FTTN providers.

My original switch from ADSL2+ to NBN was, like Carl's, painless. My ISP booked my appointment with NBNCo, and within about a week, I was switched from ADSL2+ to FTTN NBN with only 2–3 hours downtime. My speed went from 17Mbps down and 0.5Mbps up to an average of 24Mbps down and 4.5Mbps up on my ISP's basic 25Mbps/5Mbps NBN plan.

However, I found that, during peak periods (5pm–10pm), I was experiencing heavy congestion and my speed test gave me results of 6Mbps down and 3Mbps up. At some stages, I couldn't even watch Netflix. Coming from a constant ADSL2+ speed of 17Mbps, I was furious at my ISP for providing me a inconsistent NBN service. I might as well have signed up for ADSL1!

Unsatisfied, I made a few enquiries and decided it was feasible to change ISP FTTN providers. I called a different ISP and signed up for a 100/40 plan. They said there would be no downtime between churning, "a flick of the switch" were their exact words...

As soon as that switch was flicked, though, I found myself without internet for 8 days before the issue was rectified – which required a lot of legwork on my behalf. After many phone calls to both my old and new ISPs trying to get the connection working, I found everyone's hands were ultimately tied by an additional party – Optus. It turns out that, if you sign up with a provider who doesn't have what's called a POI (point of intercept) at your local node/CSA, you have to go through a third-party wholesaler who does – in this case, Optus, and any requests take a minimum of 72 hours to process and are usually not rectified quickly. To reverse the switch would have been a similar wait time with no internet.

It eventually got sorted; however, even on my new ISP, things aren't perfect. Speeds are higher at off peak times, but during peak periods,the 6Mbps down and 3Mbps up still exists. This will apparently continue until my new ISP can roll out a POI on the local node/CSA. This will give them direct access to NBNCo for any fault-related troubleshooting for congestion related complaints.

In short, I believe more transparency needs to be made available to consumers about what is available.

Slowing customers down to what are essentially ADSL1 speeds during peak periods is totally unacceptable and somebody needs to be held accountable. I hope more people share their experiences and report any similar experiences to the Telecommunications Ombudsman. **Paul Dickson**

DOWN WITH DRONES

I read with interest your news report about a drone owner receiving 30 days jail time for a drone mishap (see APC *440*, page 10).

Besides being invasive, they can be very dangerous to the public – particularly if someone has sinister intentions. So we really need stringent controls on their use.

Hopefully, we will now see an end to those nonsensical claims by prominent pizza companies and mail-order companies about home deliveries using drones. Can you imagine the carnage if one of these things accidentally crashed into or dropped their load on your windscreen while driving along a motorway in peak hour?

On a lighter note, I've already figured out that a fishnet on an extendable pole can get me a free drone and pizza in one! Drone catching might overtake Digimon as the new national pastime...

If that hobby takes off, we might also see an end to that silly 'DRU' pizza robot from Domino's – which looks like spin to sell pizzas to me! Are those things going to sit on the kerb waiting for the traffic light to change? I just can't imagine a million-dollar robot wandering the suburbs without being snatched by the local mob.

Anthony Busuttil ■

APCMAG@FUTURENET.COM

Come on, have your say!

We want to hear what you think. Add to these discussions or email your views (in fewer than 250 words) to **apcmag@futurenet.com**. All correspondence becomes the property of *APC* and is subject to editing. Letters must include full name, street address, suburb, state and phone number to be considered for print publication. Address and phone details will not be published.

Android security still a mess

New figures reveal half of Android devices aren't receiving important security updates — although Google promises that things are improving. Shaun Prescott investigates.

The best thing about Android is that it's a relatively open platform and phone manufacturers can adapt it. The worst thing about Android is that, when security updates are left in the hands of phone manufacturers, they too often fall by the wayside. In a recent report on its security progress, Google revealed that its security updates had reached 735 million devices in 2016, which, on the face of it at least, is an impressive sounding statistic. The problem is: this figure only accounts for around half of the Android install base. Globally, there are 1.4 billion active devices running Google's mobile OS.

That means one in two Android phones could be open to security breaches. The thing is, there's not much that Google can directly do to address this, because it's the manufacturers or phone-service providers who generally decide when updates will be rolled out. Reading the report, it seems to be more a matter of coordinating workflow than blatant irresponsibility on their part, but it's still undeniably a serious problem. It's one Google is still working to address. "About half of devices in use at the end of 2016 had not received a platform security update in the previous year," the company wrote in a blog post accompanying the report. "We're working to increase device security updates by streamlining our security update program to make it easier for manufacturers to deploy security patches and releasing A/B updates to make it easier for users to apply those patches."

While it's true that "blatant irresponsibility" may not be the cause for delayed security updates on some Android phones, in the end, it doesn't really matter why those updates are coming late: all that matters is that they are, and that they shouldn't. The problem is amplified by the fact that, at a guess, most people won't even be aware whether their phones are protected or not. Worse still, most will assume they are.

The report follows the great 2015 Stagefright vulnerability scare, which allowed attackers to remotely control a victim's device. At the time, Samsung announced it would work to get security updates out in a "more timely" manner. Later, the company began issuing updates at roughly the same monthly clip as Google – though these often only appeared in a timely fashion on unlocked phones that had been purchased outright, rather than those on a phone plan.

And that's seemingly the rub – not all carriers and manufacturers are following Samsung's footsteps, though the company has cut the roll-out time from 6–9 weeks down to a matter of days. Meanwhile, these parties being slow on the core security updates isn't the only problem, as outdated phones running old versions of Android are also at risk. Whatever the case, it does add to the list of "things to worry about" when shopping around for a new phone, and a little vigilance after a purchase won't go astray, either. ■

END USER

Share your stories!

If you have an interesting story about technology users, their experiences and the issues that affect us all (whether funny or serious), email us at **apcmag@futurenet.com**. All correspondence becomes the property of *APC* and is subject to editing. Letters must include writer's full name, street address, suburb, state and phone number to be considered for print publication. Address and phone details will not be published.

3D XPOINT: INTEL'S SECRET WEAPON?

Jeremy Laird asks whether the tech behind Optane is just a supercharged flash alternative or the gateway to 100GHz optical computing?

Is Intel's new 3D XPoint tech the biggest paradigm shift in computing since the introduction of silicon chips? Is it merely the basis of faster SSDs? Or is this story nothing more than a combination of vaporware and conspiracy theories?

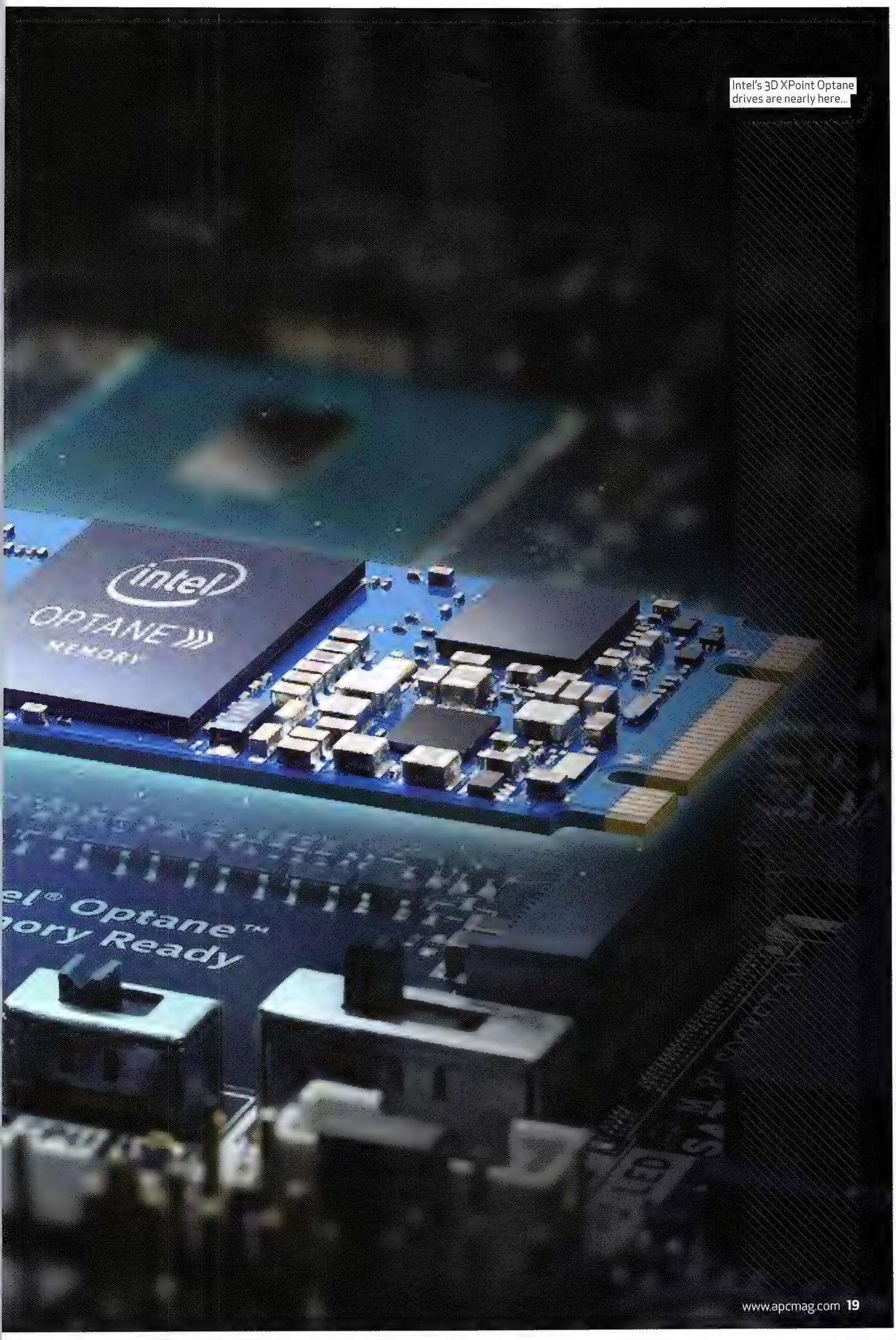
3D XPoint is one of the most mysterious technologies to come out of Intel in years. The first products derived from it have finally started to appear, yet many don't fully understand what it is or how it works. In fact, to all but a few, it's probably not even clear what it's intended to do.

That's partly down to a lack of clarity on Intel's (and its partner, Micron's) behalf. The messaging has been mixed, both in terms of the intended applications for 3D XPoint, and the insight Intel has provided into its technical underpinnings. It's the latter, in particular, that has fueled speculation. Nature abhors a vacuum, and into the space created by equivocation has flowed extensive conjecture.

Is 3D XPoint the basis for a whole new approach to chips, with chalcogenide and phase-change materials replacing silicon and the transistor? Does it open the door to fully integrated on-chip optical computing? Will it smash the circa-4GHz ceiling on CPU speeds, achieving frequencies in hundreds of gigahertz?

Meanwhile, rumours abound of corporate manoeuvering and even skulduggery. Is the patchy technical insight an attempt to protect valuable and vulnerable intellectual property? Could Intel be playing down the true value of 3D XPoint, while it scoops up the relevant patents, ensuring a lucrative lockdown on the next age of computing? Or could there be an intentional cover-up involving infringement of third-party patents?

Heady stuff. Getting to the truth, however, isn't easy. All we know is that the first 3D XPoint products will take the form of non-volatile solid-state storage, sold under the new Intel Optane brand. But even here, there's scope for confusion. The first Optane drives aren't intended to replace system memory or hard drives. Instead, they're somewhere in between — a kind of fast cache designed to act as a buffer in front of the relatively slow performance of an SSD containing NAND flash memory. With that, let us begin...



Intel's 3D XPoint Optane drives are nearly here...

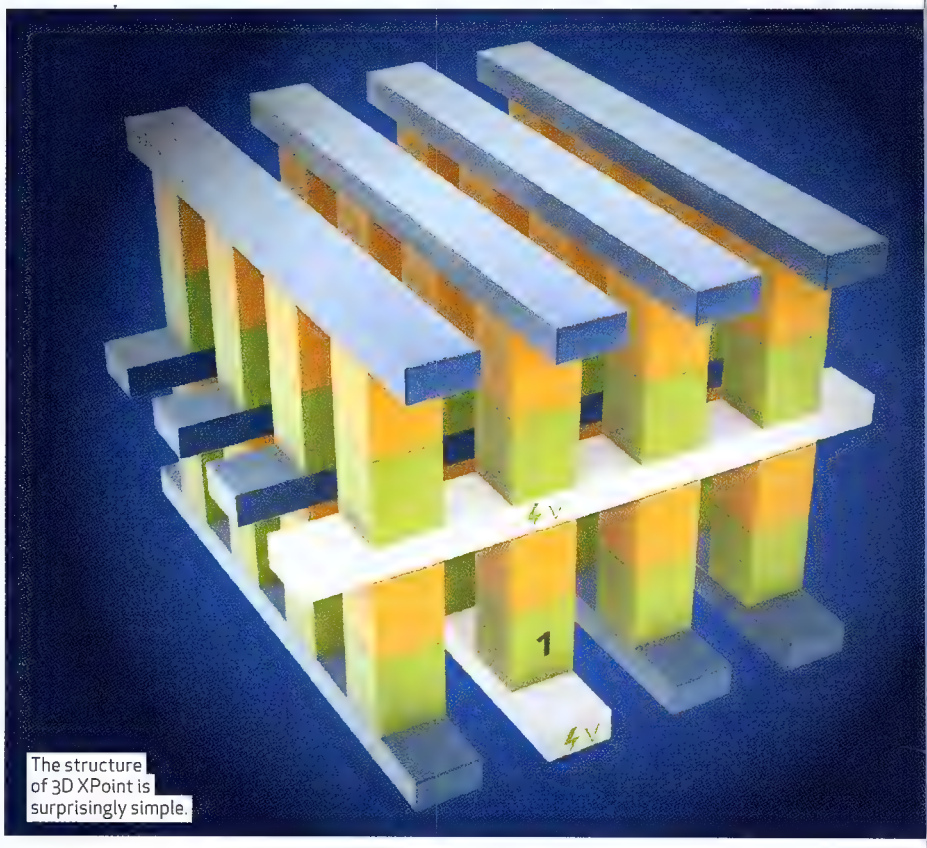
When 3D XPoint was first mooted, it was exciting simply as a new memory technology, let alone as the foundation for a whole new approach to computer chips. The industry has spent decades trying to cook up a new non-volatile storage technology with which to improve upon flash memory. Finally, here it is.

The sales pitch was stellar. In early presentations, Intel said 3D XPoint was up to 1,000 times faster and 1,000 times more durable than existing NAND flash memory. Even by the standards of the chip industry, for which exponential improvements over time are the norm, that kind of one-off step change is exotic.

The commercial reality isn't proving quite so spectacular. The first retail products based on 3D XPoint are just about to hit the market under Intel's Optane branding, and expectations have been scaled back dramatically. Specific performance data hasn't been released. But Intel is talking about Optane drives being up to 10 times faster than a conventional SSD. Still a big jump, but perhaps rather more plausible.

Let's not get ahead of ourselves. First, let's lay out what we know about 3D XPoint. Currently, there are two prevailing memory technologies, if we're talking integrated circuits rather than magnetic memory solutions, such as a hard disk. RAM or system memory is super fast and effectively lasts forever, but requires a constant electrical current. NAND or flash memory is non-volatile, so maintains data integrity without a power supply, but at the expense of speed and durability.

There are a few other details that separate the two, such as memory cell size and power consumption, both of which are relatively poor with RAM. But the holy grail for the last 20 to 30 years has been to develop a memory technology that combines the best of both: speed and durability with non-volatility. Several technologies and even whole companies promising just such a solution have come and gone over the past few decades. But 3D XPoint is arguably the first that really looks like it's going to stick.



The structure of 3D XPoint is surprisingly simple.

It's actually the work – or at least the property – of two of the biggest players in computer chips in general: Intel and Micron.

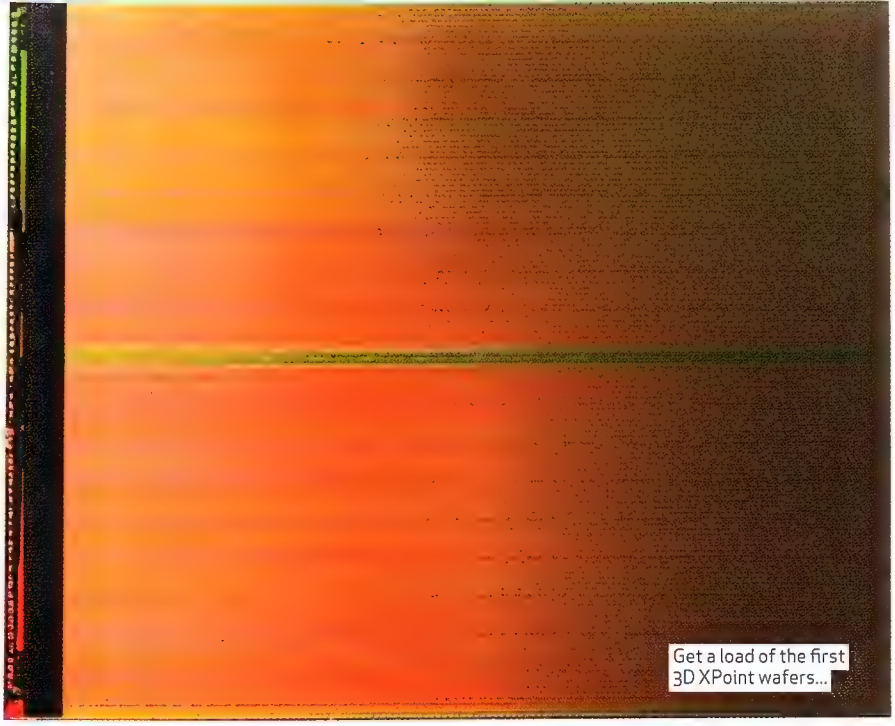
The former is best known today as a maker of PC processors, but Intel's genesis was actually as a maker of memory. Its first product was in fact DRAM, or dynamic random access memory, which remains the basis of system memory in PCs and other computing devices today. Micron, meanwhile, is well known as a maker of all kinds of memory, from sticks of DDR to solid-state drives, many of which sell under its Crucial retail branding.

Although 3D XPoint may eventually end up replacing both DRAM and NAND, for now, it's the latter that begs the most obvious comparison, not least because it, too, is a non-volatile memory type. But there are huge differences thereafter. For instance, NAND stores data by trapping electrons in an insulated floating gate. Thus, each memory cell is a sort of capacitor, with the charged or discharged state representing a bit of data.

3D XPoint, by contrast, is a resistance-based technology that uses bulk property change to the cell material to alter its resistance level, and so record a memory state. When you drill right down to cell level, 3D XPoint also has a remarkably simple structure. There's the memory cell itself, a switch or selector element, then the connecting wires. And that's really it. The cleverness comes in the materials and how it's all arranged.

Currently, Intel and Micron haven't revealed all the details, leaving space for speculation as to the full implications of the technology. But what is clear is that the bitline and wordline connecting wires are arranged above and below the cells, and laid perpendicular to one another, in a grid pattern, hence the 'XPoint' or crosspoint moniker.

Intel is making big claims for 3D XPoint performance.



Get a load of the first 3D XPoint wafers...

There are some immediate benefits that come out of all that. For starters, the simplicity of the structure, including the notable lack of a transistor, makes for excellent cell density. In other words, you can pack in more data, especially compared to DRAM. What's more, the 'crosspoint' wiring means the data is addressable at individual bit level. This has all kinds of upsides compared to NAND flash, which must be read and written in large blocks.

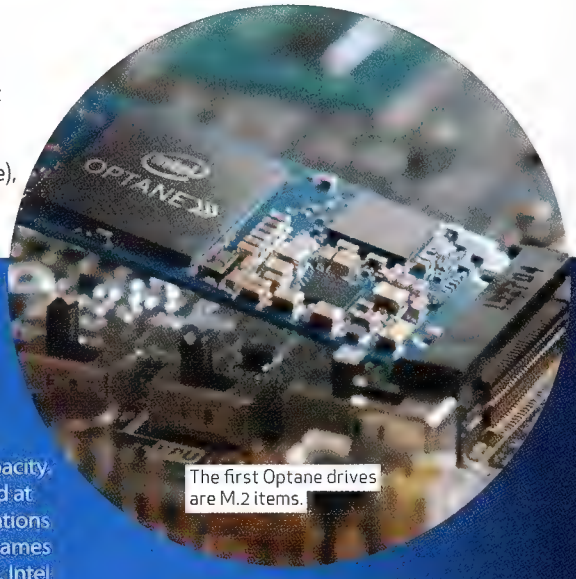
The latter is a reasonable approach when reading or writing large chunks of data, but it quickly becomes inefficient with random access workloads involving high-frequency requests to read and write little snippets of data. The net result is that you end up reading and writing large amounts of redundant data. By enabling bit-level access to data, 3D XPoint has NAND flash dramatically beaten for speed and latency.

As we mentioned earlier, 3D XPoint is also claimed to offer up to 1,000 times better endurance than NAND. That makes for something in the order of a few million write-erase cycles, or hundreds of petabytes of writes overall, and hundreds of terabytes of writes per day. So, for most users, an SSD using 3D XPoint technology could be considered to last forever. It will never wear out.

Overall, the broad picture for the first implementation of 3D XPoint in Optane drives puts its capabilities roughly between DRAM and NAND, but arguably closer to the former. It's far faster than NAND, but not as fast as DRAM. Likewise, it's much denser than DRAM in terms of data storage, but not quite as dense as NAND.

If that's what we know for sure today, how will 3D XPoint deliver in the future, and could it really be the beginning of a new age of computing? In the short to medium term, it seems fairly certain that Optane drives will transition from cache drives into general storage. The first Optane products have been announced at 16GB and 32GB capacities, using a production node roughly equivalent to 20nm transistors (without any transistors, direct comparisons of feature size become quite subjective), reflecting the relatively high cost of the very first 3D XPoint chips. Prices haven't been announced, but as Intel and Micron get to grips with production, we expect to see the cost come down fairly rapidly. Within a couple of years at most, Optane drives measuring hundreds of gigabytes and more should be available at prices normal consumers can afford.

It's everything beyond that where things get complicated. For instance,



The first Optane drives are M.2 items.

INTEL'S OPTANE: 3D XPOINT IS GO FOR LAUNCH

It's going to be a while before we'll be able to uncover the full implications of Intel's 3D XPoint tech. But we do now know what shape the first products will take. At CES in Las Vegas, earlier this year, Intel divulged initial details of its first 3D XPoint products.

To be sold under the new Optane brand, we're talking solid-state storage in the M.2 form factor, and initially 16GB and 32GB capacities. Somewhat oddly, the marketing pitch for Optane has involved the shortcomings of using a "spinning hard disk" for data storage. That's true, of course, but the fact that Optane drives are solid state and faster than magnetic hard drives surely isn't what sets them apart. It's the distinction compared to existing solid-state drives that makes Optane interesting.

Whatever, Optane drives are being pitched as a disk drive cache memory option for its seventh-gen Kaby Lake processors and platforms. To quote: "Intel Optane memory is a revolutionary new memory technology that affordably accelerates your system, delivering high speed and responsiveness without compromising system storage capacity. When combined with a large storage drive, the Intel Optane memory M.2 module accelerates computer performance, while maintaining capacity. You'll be amazed at how fast applications launch or new games install. Together, Intel Optane memory and a seventh-generation Intel Core i-series processor deliver a snappy PC experience with short boot times, fast application launches, extraordinary gaming experience, and responsive browsing."

You will, as we understand it, need the full Kaby Lake package to use an Optane drive. That means a Core iSomething-7xxx CPU and a motherboard with Optane support, based on Intel's new 200 Series chipsets.

Exactly what we can expect in terms of performance boosts, whether Optane will play nicely with both HDDs and SSDs, and so on isn't yet clear. Our guess is that the very first products could be underwhelming, and will be held back by things like the controller technology and other specifics related to the early implementation. But with any luck, we're only a month or two away from revealing 3D XPoint's first tranche of secrets.

REBOOTING MOORE'S LAW

Is the end nigh for Moore's Law? You could certainly make that case. After all, it's true that the computer chip industry has had a tricky few years of late, keeping up with the pace of progress that Moore's Law implies.

Lest you have forgotten, Moore's Law is simply the observation that transistor densities in integrated circuits tend to double every two years. Put another way, Moore's Law says computer chips either double in complexity and thus performance, or halve in cost — or some mix of the two, depending on what you're after — every couple of years.

It dates back to the 1960s or 1970s, depending on the part of the technological folklore you want to focus on. But the point is that it undeniably proved prescient for several decades. More recently, it's come into doubt. Whether Moore's Law has really hit a wall will only become clear several years from now. What we can say is that big players like Intel and TSMC — the latter being the foundry responsible for making most AMD and Nvidia GPUs in recent memory — have missed several self-imposed targets when it comes to new production nodes and shrinking their transistors.

The situation has become acute enough for Intel to abandon its so-called Tick-Tock cadence of a new CPU architecture and production process in alternating years, as dictated by Moore's Law. Instead, Intel has switched to a three-year cadence of process, architecture and optimisation.

Meanwhile, it's also undeniable that CPU operating frequencies have hit something of a wall around roughly 4GHz. In the good old days when MHz ruled, CPUs would benefit from both process shrinks and increased frequencies. Not any longer.

It's just possible, however, that 3D XPoint's chalcogenide underpinnings could reboot Moore's Law, at least for a time. The structure is completely different, so the fact that transistor gate sizes are running up against the laws of physics suddenly becomes irrelevant. 3D XPoint's chalcogenide devices don't use transistors. Likewise, chalcogenide devices have at least the theoretical potential to hit insanely high frequencies, well beyond those seen in commercial silicon chips. Whether any of this becomes a practical reality, only time will tell. But it's fun to know that it's possible we're on the cusp of a new wave of computing.

Is Intel's Kaby Lake CPU family the last of a dying breed of silicon chips?

co-CEO Guy Blalock of the IMFT Intel-Micron joint venture responsible for 3D XPoint has said, "3D XPoint specifically offers a path to provide massive amounts of memory storage at a latency rate sufficient to place it in close proximity to the CPU." Intriguing, but what does it actually mean? It's not exactly saying that 3D XPoint is poised to replace DRAM. But it's also placing it in an unambiguously different position in the system hierarchy compared to existing solid-state drives. Overall, it points to a new class of memory that's difficult to currently define.

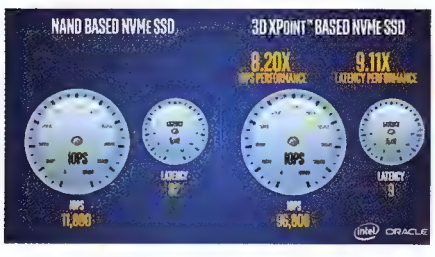
Even more significantly, however, could 3D XPoint be the basis of a new age of post-silicon computing? At this point, a warning is required. Much of what follows is highly speculative, though the scope for speculation is at least in part due to Intel and Micron's failure to provide clarity on some of the technical details.

Much of the speculation revolves around the materials and operational specifics of 3D XPoint. Some earlier speculation implied it depended on phase-change physics to store data, an approach that has been under evaluation for non-volatile memory for some time. Phase-change memory is built around a material known as chalcogenide glass, which sports some pretty funky properties. In simple terms, chalcogenide can be switched between amorphous and crystalline solid states or phases, courtesy of applying an electrical current. What's more, a number of distinct intermediate states can also be achieved. Amorphous versus crystalline gives you 0 and 1 for the storage of a single bit, obviously. The intermediate states allow for multiple bits of memory per cell.

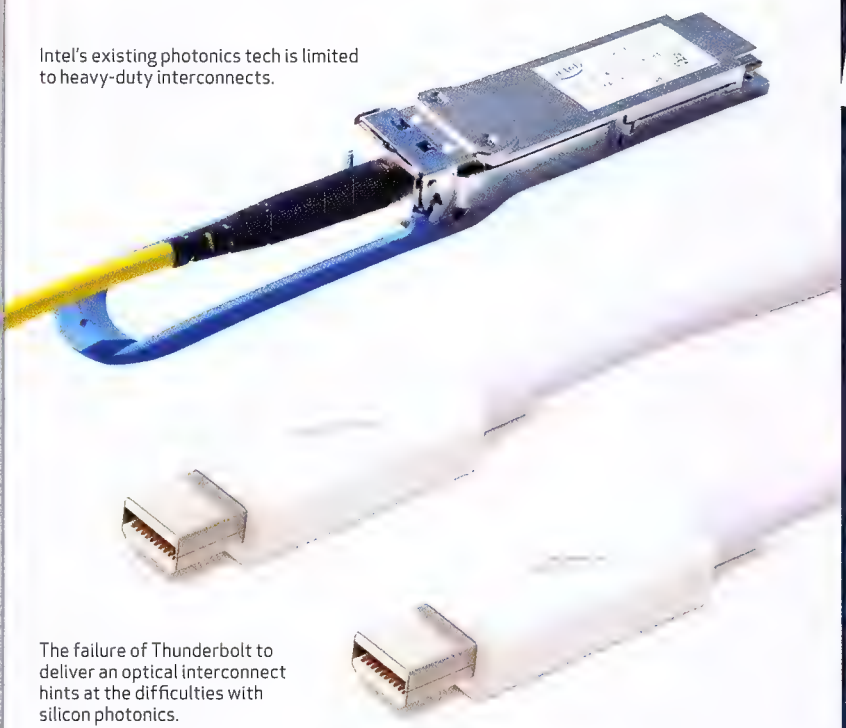
Multiple companies, including IBM, Samsung, Numonyx and Intel, have been working on phase-change memory, or PRAM, for some time. However, Intel and Micron have repeatedly denied that 3D XPoint depends upon phase-change physics. For instance, when UK tech site The Register put the question to Micron regarding 3D XPoint's use of phase-change materials, it was told, "3D XPoint technology is a new class of non-volatile memory invented by Intel and Micron that relies on resistance change of the bulk material to achieve non-volatility. Unlike phase-change memory, 3D XPoint technology uses a unique cross point architecture, enabling it to scale in ways that phase-change memory has not been able to accomplish." That's a pretty unambiguous denial that 3D XPoint is a phase-change memory technology. So why are we even discussing it?

How about this quote in reference to 3D XPoint, again from Guy Blalock of the IMFT? "Chalcogenide material and an Ovonyx switch are magic parts of this technology, with the original work starting back in the 1960s." So 3D XPoint is a chalcogenide device and builds on its development of that material in a computing context since the 1960s, which has been primarily centred on its phase-change properties. All very confusing.

This is where the conspiracy theories come in. Are Intel and Micron obscuring 3D XPoint's phase-change properties with a view to sidestepping patents they don't own? Could it be a double bluff, in which they imply that it's phase-change by indicating that the core tech is chalcogenide, because they're either in the process of acquiring patents for something else, or know it can't be protected and want to give themselves as big a head start over the competition as possible? Who knows?



Intel is certainly making impressive performance claims for its new Optane drives.



Intel's existing photonics tech is limited to heavy-duty interconnects.

The failure of Thunderbolt to deliver an optical interconnect hints at the difficulties with silicon photonics.

Where things get even more speculative is 3D XPoint's role as a candidate technology for non-memory devices. Some commentators speculate that transistor-less chalcogenide devices similar to those used in 3D XPoint memory cells are good candidates for replacing the transistor itself, and could operate at speeds far higher than silicon chips. Switching speeds measured in hundreds of gigahertz are mooted, and the simplicity of the internal structure could allow for additional scaling in device density, too. Put the two together and you have a roadmap that keeps the computer industry rolling for some time, just when conventional silicon chips are increasingly running up against the laws of physics.

Another more specific avenue by which 3D XPoint might be implicated in new approaches to computing involves optical technology, or photonics – using light, rather than electrons, as the basis for computing. Photonics, of course, already exists as a computing technology, most obviously as a superfast data interconnect in the form of fibre optics. The fact that light is the ultimate in high-speed comms is a hint of its broader potential. Indeed, much of the backbone of the internet, which is built out of fibre optics, depends on just that potential.

The argument as it relates to 3D XPoint, photonics and computing goes something like this: Currently, integrating photonics into a computing platform requires dedicated chips. It's not possible to put silicon photonics on to the same chip as a high-performance computing circuit like a CPU. However, chalcogenide devices, according to some, solve that problem. Indeed, chalcogenide photonics is a science all of its own.

Taking the discussion any further, unfortunately, is almost impossible. We simply don't know whether Intel and Micron have plans beyond solid-state memory when it comes to 3D XPoint. It's true that the use of chalcogenide devices is extremely novel, but even the best qualified engineers and scientists can't say for sure where the limits lie for chalcogenide as a candidate material for replacing silicon and transistors.

If Intel and Micron have made some major breakthroughs, the only thing you can be sure about is that they'd be keeping their cards close to their chests until they were either certain they had the relevant intellectual property on total lockdown or, if that wasn't possible, until they were absolutely ready to launch products. The truth will out eventually. Watch this space, as we'll be testing Optane very soon.

RYZEN

DOES 3D XPOINT SPELL DOOM FOR AMD?

By the time you read these very words, AMD could be back on roaring form. The first of its Ryzen CPUs have launched, and the early indications are that the new architecture is going to sock it straight to Intel with CPU models up to eight cores and, therefore, give $1,000 Core i7 CPUs a run for their money at less than half the price.

Intel, of course, will hardly be blown out of the water. It's been taking things very easy in recent years, and has quite a bit of performance in hand. It can easily up its game, and no doubt will. But there's also a chance that 3D XPoint could give Intel a killer advantage, even without taking into account the more exotic end of the spectrum of possibilities that involve 3D XPoint-derived technology replacing CPUs wholesale.

Instead, we're talking about what's required to make the most of 3D XPoint as a memory and storage technology with conventional platforms and silicon processors. As we've seen, 3D XPoint has the potential to deliver a huge jump in solid-state storage performance. The benefit of that is obvious, but it's also theoretical. A storage technology that's 10 times faster than NAND simply has no way to talk to the CPU on existing platforms without either a huge performance hit or soaking up bandwidth that's critical for other components like graphics. That's the problem.

Instead, to make the most of 3D XPoint technology, new on-CPU interconnects and controllers will be needed. It goes without saying, Intel will be far, far better placed to design and implement them than AMD. It's not hard to imagine Intel shipping CPUs with on-package dollops of 3D XPoint memory measuring tens or hundreds of gigabytes, and offering stellar storage performance, thanks to clever caching features, for instance.

Maybe the solution will be along the lines of a new type of memory controller and data addressing, which can neatly speak to RAM and 3D XPoint memory in parallel, in some kind of shared memory space. Either way, at best, AMD would be years behind, playing catch-up. If Intel can lock AMD out via patents or similar intellectual property restrictions, on the other hand, AMD could be out of the 3D XPoint game altogether, and with devastating consequences.

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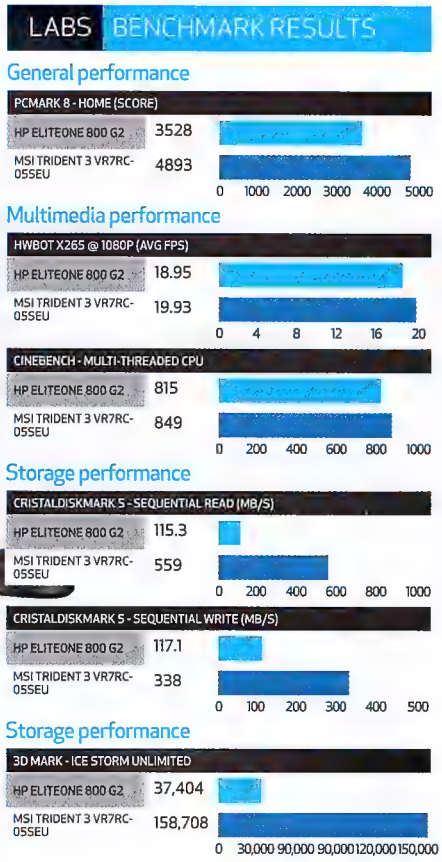
LABS BENCHMARK RESULTS
General performance
PCMARK 8 - HOME (SCORE)
HP ELITEONE 800 G2 3528
MSI TRIDENT 3 VR7RC-055EU 4893
0 1000 2000 3000 4000 5000
Multimedia performance
HWBOT X265 @ 1080P (AVG FPS)
HP ELITEONE 800 G2 18.95
MSI TRIDENT 3 VR7RC-055EU 19.93
0 4 8 12 16 20
CINEBENCH - MULTI-THREADED CPU
HP ELITEONE 800 G2 815
MSI TRIDENT 3 VR7RC-055EU 849
0 200 400 600 800 1000
Storage performance
CRISTALDISKMARK 5 - SEQUENTIAL READ (MB/S)
HP ELITEONE 800 G2 115.3
MSI TRIDENT 3 VR7RC-055EU 559
0 200 400 600 800 1000
CRISTALDISKMARK 5 - SEQUENTIAL WRITE (MB/S)
HP ELITEONE 800 G2 117.1
MSI TRIDENT 3 VR7RC-055EU 338
0 100 200 300 400 500
Storage performance
3D MARK - ICE STORM UNLIMITED
HP ELITEONE 800 G2 37,404
MSI TRIDENT 3 VR7RC-055EU 158,708
0 30,000 90,000 90,000 120,000 150,000

HP EliteOne 800 G2

An all-in-one that's elite in price, but sadly not in value.

For a 23-inch screen that manages to pack an entire PC onto it's back, HP's Elite One 800 is surprisingly slim at just 59mm thick. It's a design that borrows from Apple's recent freestanding iMacs, with the screen and bezel covering around 95% of the total front face of the unit and a silver speaker bar capping the bottom edge. While it might be iMac-like in overall theme, the EliteOne 800 shirks on the details.

The screen bezel, for example, is unfortunately large – over an inch thick on it's narrowest edges – which gives the computer a dated overall appearance. Adding to this 'mature' aesthetic, our review unit came with the 64-bit version of Windows 7 Professional pre-installed, presumably aiming for business users who already have systems running Microsoft's now legacy OS. Thankfully, you can swap it out for Windows 10 Pro, if desired. The main drawcard of the EliteOne 800, however, is probably that 23-inch, 1080p display with 10-point capacitive touch built-in – making it quite clear that this is at least a reasonably modern desktop PC.

Fitted with a high-end (but previous-gen) Intel Core i7-6700 CPU, the EliteOne has plenty of horsepower when it comes to tackling work tasks. In the PCMark 8 Work Accelerated benchmark, the unit scored 4,997 – that's good, but this year's laptops can match it (the newer laptop-grade Kaby Lake Core i7-7700HQ CPU in Gigabyte's Sabre 15, page 28, output a near identical score). Flick that focus to Cinebench's multi-threaded and single-core CPU tests however, and you get impressive scores of 815 and 171, higher than the Sabre 15's respective scores of 735 and 161 in these intensive image-rendering tasks.

This PC's 1TB mechanical hard drive offers ample storage, but with read and write scores maxing out at around 116MB/s apiece, this 5400RPM disk drive makes the OS boot times sluggish and any file transfers a time-consuming chore. The local HP store lets you customise to swap in an SSD for the HDD (starting at 256GB), which will undoubtedly remedy the slow start times, but we'd recommend having both a small SSD and a large HDD, so you can have quick boot times and space for an extra $120 dollars or so.

The pivotal feature of this unit is really its Full HD touchscreen – so much so that, if being able to control the computer with your finger isn't something you are looking for (or you could even do without), then there's very little value here. That said, 23-inch touchscreen monitors are hard to come by and generally cost around $500 on their own, which makes the $2,115 cost of the EliteOne 800 2G a little more palatable. There was a decent $500 dollar discount on this model on the HP store at the time of writing, which makes the unit much better value and worth holding out for if you can.

The PC's integrated Intel HD Graphics 530 chip is a little lackluster, and though the PC has ample connectivity options, including; an SD Card slot, USB Type-C connector, a Displayport and Ethernet input, this is hardly a selling point. The one saving grace might be the Bang and Olufsen speakers that taper the lower edge of the screen that have nicely balanced clear sound, but they're not good enough to salvage this pricy build-yourself PC.

Joel Burgess

Verdict

Features	★★★
Performance	★★★½
Value	★★

A powerful and large desktop PC for anyone needing a touch screen, but it doesn't offer great value.

★★½

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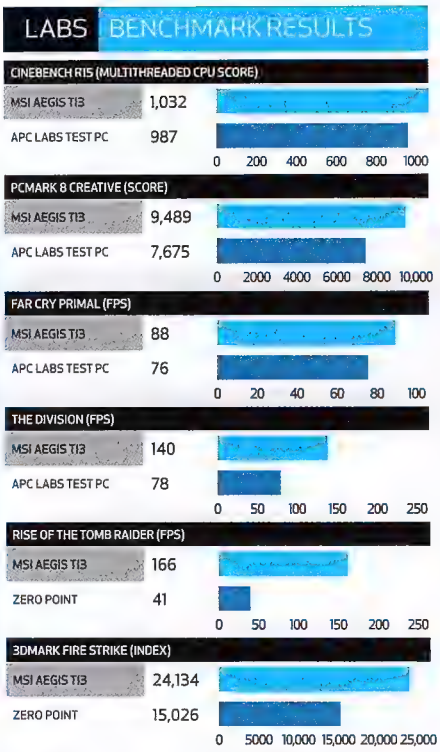
LABS BENCHMARK RESULTS
CINEBENCH R15 (MULTITHREADED CPU SCORE)
MSI AEGIS TI3 1,032
APC LABS TEST PC 987
0 200 400 600 800 1000
PCMARK 8 CREATIVE (SCORE)
MSI AEGIS TI3 9,489
APC LABS TEST PC 7,675
0 2000 4000 6000 8000 10,000
FAR CRY PRIMAL (FPS)
MSI AEGIS TI3 88
APC LABS TEST PC 76
0 20 40 60 80 100
THE DIVISION (FPS)
MSI AEGIS TI3 140
APC LABS TEST PC 78
0 50 100 150 200 250
RISE OF THE TOMB RAIDER (FPS)
MSI AEGIS TI3 166
ZERO POINT 41
0 50 100 150 200 250
3DMARK FIRE STRIKE (INDEX)
MSI AEGIS TI3 24,134
ZERO POINT 15,026
0 5000 10,000 15,000 20,000 25,000

Our APC Labs test PC has a Core i7-6700K overclocked to 4.6GHz, an XFX Radeon R9 Fury X, 32GB of Kingston HyperX Savage DDR4-2400, and a 256GB Samsung 950 Pro, mounted on an ASUS Z170I Pro Gaming motherboard.

MSI Aegis Ti3

Mean machine makes a mega impression.

We've taken to calling the Aegis Ti3 'Optimus Prime' around the office, though perhaps 'Megatron' is more appropriate with those angular features and red and black styling, but we can't hold that against it – especially considering the power locked inside.

The Ti3 marks the third generation of MSI's Aegis gaming desktops, and this iteration updates the system with an Intel Kaby Lake processor – a 4.2GHz Core i7-7700K, with the turbo raised from 4.5 to 4.8GHz. Also slotted in the MSI Z270 motherboard is a ludicrous 64GB of DDR4-2400 RAM – an absurd amount.

The result is solid scores in Cinebench R15 (1,032) and Tech ARP's x264 (23.22fps), though x264 crashed the first few times we tried running it. Apparently, the factory CPU bump was only done to the clock speed, not the voltage, resulting in some instability under heavy load. It was only after bumping the voltage up a tad that the test completed without a hitch.

On the storage front, a pair of M.2 drives in RAID 0 amount to 1TB of NVMe SSD space for all your games, programs and OS, while a 3TB HDD takes care of media cold storage. But what the SSDs have in sheer size, they lose in performance, falling short of our zero-point in CrystalDiskMark x64's 4K read and write tests. PCMark 8 Creative wasn't too affected by the drive access, producing a healthy overall result of 9,489.

But Aegis Ti3 is a gaming system first and foremost. To prove it, pixel-pushing is handled by a pair of GTX 1080s in SLI. We've had some issues with SLI performance in the past – especially at 1080p – but things are considerably better now, due to updated drivers. We performed testing on Nvidia's 378.78 drivers, which added SLI profiles for a handful of games, as well as optimisations for DirectX 12. The latter proved considerably helpful in *Rise of the Tomb Raider*. With it enabled, the Aegis Ti3 landed some of the best scores we've ever seen. At 1080p max settings, the Ti3 averaged 166fps across the game's three-part benchmark. 1440p and 4K performance was just as impressive, averaging 151fps in the former and 87fps in the latter – both at max settings. *The Division* fared similarly, with 140fps at 1080p, 105 at 1440p, and 65 at 4K. Those numbers were without DirectX 12, though, because enabling it resulted in knocking our frame rates down by around 30%. Continuing to be one of the most difficult games to land a high frame rate at lower resolutions, *Far Cry Primal* scored 88fps at 1080p and 87 at 1440p max settings. 4K wasn't much below that either, with 72fps – again, with settings at the highest preset. Lastly, 3DMark Fire Strike returned excellent scores: 24,134 for the regular 1080p test, 16,074 at 1440p, and 9,115 in the 4K gauntlet of Fire Strike Ultra.

All told, the Aegis Ti3 is an incredibly capable gaming machine. Though a bit odd to look at, it's actually quite compact considering how much is inside. The carrying handle is a nice touch, too, making the system easy to tote, despite its weight (14kg). But hopefully you're happy with the insides – as according to stickers on the back panel screws, opening the case violates the warranty. ■ **Bo Moore**

Verdict

Features ★★★★½
Performance ★★★★★
Value ★★★☆☆

Outstanding gaming performance, tons of storage and surprisingly slim, but oof, that price hurts a bit.

★★★★☆

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LABS BENCHMARK RESULTS

General performance

PCMARK 8 - HOME (SCORE)

TOSHIBA PORTÉGÉ	3277
RAZER BLADE STEALTH EARLY 2017	2795

0 1000 2000 3000 4000 5000

Media encoding performance

HWBOT X265 (AVG FPS)

TOSHIBA PORTÉGÉ	8.17
RAZER BLADE STEALTH EARLY 2017	8.61

0 2 4 6 8 10

Storage performance

CRISTALDISKMARK 5 - SEQUENTIAL READ (MB/S)

TOSHIBA PORTÉGÉ	3060
RAZER BLADE STEALTH EARLY 2017	1575

0 1000 2000 3000 4000 5000

CRISTALDISKMARK 5 - SEQUENTIAL WRITE (MB/S)

TOSHIBA PORTÉGÉ	1604
RAZER BLADE STEALTH EARLY 2017	314.3

0 400 800 1200 1600 2000

Gaming performance

3D MARK - ICE STORM UNLIMITED

TOSHIBA PORTÉGÉ	63,885
RAZER BLADE STEALTH EARLY 2017	65,631

0 20,000 40,000 60,000 80,000 100,000

Battery life

PCMARK 8 - HOME BATTERY ACCELERATED (HR:MIN)

TOSHIBA PORTÉGÉ	03:38
RAZER BLADE STEALTH EARLY 2017	03:41

0 1 2 3 4 5

Toshiba Portégé X20W-D

A lesson in why you shouldn't always judge an ultrabook by its cover.

After casting your eyes and hands over Toshiba's latest Portégé, we'd forgive you for thinking it was one of the company's low-end, 'high-school laptop' compliant Chromebooks. That's not the first impression you'd expect (or want) from a high-end $2,000-plus ultrabook, but apparently 'premium feel' was one of the things that had to go with the X20W's 'Thinner, Lighter, Faster' brief. That may sound harsh, and if you slice it another way, it is clear that stripping some of the pedigree out of this laptop's exterior design has facilitated considerable gains in overall weight and functionality – enough to make an argument that it's worth considering for anyone looking for a highly functional work unit.

For starters, it's encased in an ultra-lightweight painted magnesium case that we don't expect to be overly good at resisting transport damage and is largely responsible for giving the unit its cheap plastic feel. But this lightweight exterior is key to being able to make it notably lighter overall – it's a tiny 1.1kg. And that's one of the key factors in the X20 being one of the rare hybrids that actually feels natural in both laptop and tablet modes. In fact, the well balanced stylus, 12.5-inch 1080p capacitive touchscreen and sturdy 360° foldable hinge combine to put the X20W up there with Microsoft's tablet-first Surface Pro 4 when it comes to slate-mode performance and versatility.

It isn't just a success as a tablet though. The X20 also does an excellent turn as a ultrabook. Yes, the keyboard does have slightly small and mushy keys that even Trump would say are too small, and the trackpad could do with more surface area and less asymmetrical edges, but both are perfectly functional and work well once you get used to their mild quirks. And if you peer beneath the surface, you'll find the X20W smuggling in a powerful Intel Core i7-7600U, a whopping 16GB of DDR3 RAM and a generous 512GB SSD that's connected via the absurdly fast PCIe bus. This premium spec sheet means the Portégé X20 can spin a PCMark 8 Home score of 3,277, crank out 1080p media encoding rates of 8.17fps and float sequential read and write speeds of 3,060MB/s and 1,604MB/s, respectively. All of which add up to a level of performance that's almost inexplicable in such a compact 15.4mm-thick, 1.1kg package.

The performance prowess of the Portégé doesn't end there though with integrated Intel HD Graphics 620 managing to wrangle impressive 3D-rendering and gaming scores. The X20W's downward-firing stereo speakers are surprisingly loud for a small unit and produce a clean sound. All this power does have it's downsides, though, with the most noteworthy being the 3 hours and 38 minutes battery life (that's in PCMark 8's admittedly-tough Home benchmark) and rather toasty peak CPU temperatures of 88°C. While that battery benchmark score will get near a full day's light usage for many users, it's still a little less than we'd like in an ultraportable – and a good couple of hours behind the likes of Dell's XPS 13. The matte screen could also perhaps be a little more vibrant. But really, our main gripes with this one are cosmetic and financial – from a functional view, there's not much wanting here, although you do have to pay for it.

Joel Burgess

Verdict

Features	★★★½☆
Performance	★★★★½
Value	★★½☆☆

Powerful and functional, but it's very high-priced and feels a little flimsy for a premium ultrabook.

★★★½☆

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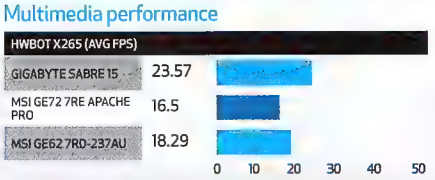
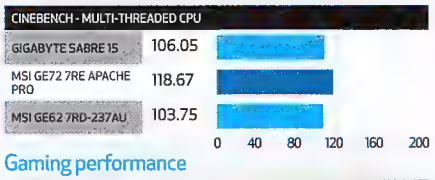
LABS BENCHMARK RESULTS

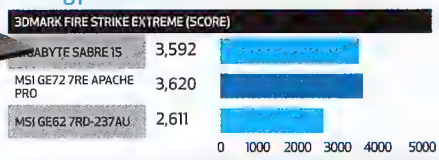
General performance

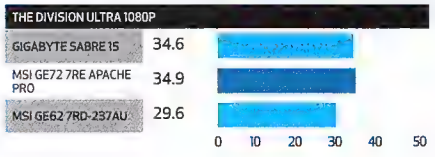
Multimedia performance




CINEBENCH - MULTI-THREADED CPU
GIGABYTE SABRE 15 106.05
MSI GE72 7RE APACHE PRO 118.67
MSI GE62 7RD-237AU 103.75
0 40 80 120 160 200

Gaming performance


3DMARK FIRE STRIKE EXTREME (SCORE)
GIGABYTE SABRE 15 3,592
MSI GE72 7RE APACHE PRO 3,620
MSI GE62 7RD-237AU 2,611
0 1000 2000 3000 4000 5000



Gigabyte Sabre 15

A budget gaming laptop that makes cuts in all the right places.

Nowadays, gaming laptops can generally be placed into one of three broad categories: the 'Mad Max' power systems; the well-specced gaming ultrabook; or those that belong in the bargain bin – which is never really all that 'budget' when it comes to gaming laptops. The new Sabre range from Gigabyte is squarely aimed at picking up price-conscious customers shopping for the latter type, and since you can get this Sabre 15 with a Nvidia GTX 1050 for as little as $1,749, we think it'll have no trouble doing just that.

There are inevitably some sacrifices that have to be made to get the price this low, but fortunately, on the Sabre 15, those cuts are largely cosmetic. Kicking it off is a smooth black plastic that wraps the entire laptop. This type of shell often leads to a flimsy chassis on lower-end rigs but it's nice and sturdy here (something aided by the machine's robust 2.7cm thickness) and while the Sabre's 15.5-inch 1080p screen is a little more flexible than we'd like, we've seen significantly worse. Gigabyte has also refrained from going overboard with colourful gaming highlights and decals – though there are configurable key backlights ,plus an interesting black-on-black plastic mould that makes this bulky 2.3kg unit look like a Bat Mobile.

Built around one of Intel's top seventh-generation mobile CPUs (the Intel Core i7-7700HQ), the Sabre 15 doesn't cut corners when it comes to hardware, despite its penny-pinching agenda. This CPU managed to power through general work and home tasks, matching last year's desktop chips of the same tier as seen in HP's EliteOne 800 G2 (see page 25). This CPU is backed up by one of Nvidia's latest GTX 1050 Ti GPUs with 4GB of dedicated VRAM, which helped it score solid results Cinebench's OpenGL benchmark and 3DMark Fire Strike Extreme (106.05fps and 3,592, respectively). Those impressive scores are bolstered with the system's generous 16GB of RAM, and translate to real world 1080p 'Ultra' average framerates of 70, 34.6 and 113.23fps on *Batman: Arkham Knight*, *The Division* and *GRID 2*. These scores were fractionally better than what we saw on MSI's similarly specced GS72 7RE, which got 62, 34.9 and 97.28fps, respectively.

Gigabyte has even chosen to add a bigger 256GB SSD (the norm here is 128GB) as the primary hard drive, with a 1TB Hitachi HDD for bulk storage – although to compensate, the SSD isn't a PCIe model, instead it's one of the slower SATA 6Gbps units. On balance, double the space for a cut in speed seems reasonable tradeoff on a budget device, and that SSD still manages to hit 554.2MB/s and 395.7MB/s sequential read and write speeds – much quicker than any mechanical drive.

With an RRP of $1,899, the Sabre 15 manages to undercut its competition by about $200 for a near identical setup, which is an exciting prospect for a price conscious market.

With a battery life of 2 hours and 53 minutes in PCMark 8's Home battery benchmark, reasonable 86°C maximum CPU temperatures, acceptable-quality stereo speakers and ample connectivity options, means that, at this price, we are at a loss to fault this unit in any considerable way.

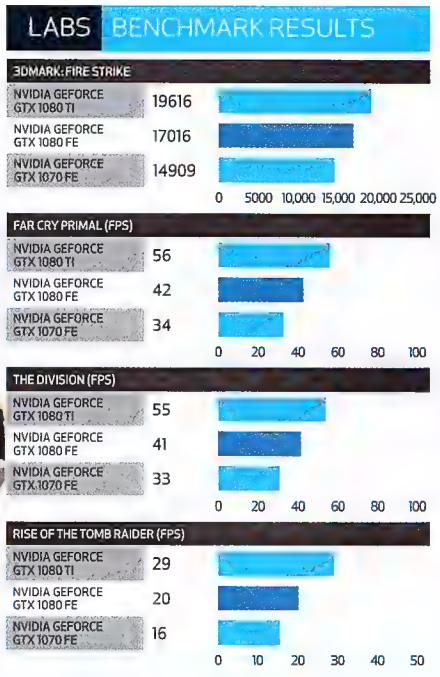
Joel Burgess

Verdict

Features ★★★★½
Performance ★★★★½
Value ★★★★★

An excellent entry-level gaming laptop that's a little bulky, but will allow you to play new titles at reasonable settings.

★★★★½


LABS BENCHMARK RESULTS
3DMARK: FIRE STRIKE
NVIDIA GEFORCE GTX 1080 TI 19616
NVIDIA GEFORCE GTX 1080 FE 17016
NVIDIA GEFORCE GTX 1070 FE 14909
0 5000 10,000 15,000 20,000 25,000
FAR CRY PRIMAL (FPS)
NVIDIA GEFORCE GTX 1080 TI 56
NVIDIA GEFORCE GTX 1080 FE 42
NVIDIA GEFORCE GTX 1070 FE 34
0 20 40 60 80 100
THE DIVISION (FPS)
NVIDIA GEFORCE GTX 1080 TI 55
NVIDIA GEFORCE GTX 1080 FE 41
NVIDIA GEFORCE GTX 1070 FE 33
0 20 40 60 80 100
RISE OF THE TOMB RAIDER (FPS)
NVIDIA GEFORCE GTX 1080 TI 29
NVIDIA GEFORCE GTX 1080 FE 20
NVIDIA GEFORCE GTX 1070 FE 16
0 10 20 30 40 50

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Nvidia GeForce GTX 1080 Ti

All hail Pascal, the new king... again?

A year ago, we reviewed Nvidia's first Pascal card, the GTX 1080. Coming in at $1,100, it shocked the tech sphere with its exceptional performance. It wasn't just a rebadge, or a meager 10% improvement over the previous generation, but a card that took the last-gen Titan X and threw it to the curb. Nvidia justified the price by saying it was just right for the stunning level of performance. The tech community faltered – a card that would usually cost around $700 was hit by an increase of almost 40%.

10 months later, the ecosystem hasn't changed. Nvidia is still ruling the roost when it comes to those heady graphical heights, and with the developer-focused Titan X coming in at an eye-watering $1,700, for what amounts to a 10–15% performance increase over its GTX 1080 sibling, the GTX 1080 was the go-to choice. Until now.

The new GTX 1080 Ti costs $1,130. It sits eagerly between the GTX 1080 and Titan XP early adopters. Featuring the same full-fat 12 billion transistor-laden GP102 core found in the Titan XP, the Ti also comes with the same 3,584 CUDA cores and 224 Texture Units. The big one, though, is the VRAM, or rather the butchering that's occurred to that poor Titan's core: 11GB of GDDR5X, instead of 12GB, a 352-bit bus versus a 384-bit memory bus, and, of course, 88 ROPs – eight fewer than the XP. Apart from that, the Ti gets some significant upgrades when it comes to clock speeds. It has a tighter and higher base to boost clock, and also comes packing an 11Gb/s memory clock, versus the rest of the 1000 series's 10Gb/s.

Performance is very impressive. This is the first card we've seen hit near enough 60fps averages in our testing suite at 4K, with all the tests ramped up, hitting 56fps in Far Cry Primal, and 55 in The Division. Rise of the Tomb Raider still tanks fairly low, at console-level frame rates, hitting 29fps, with Attila matching at 27, but all in all, it's good.

GPU Boost helps no end, with our particular retail card hitting 1,800MHz on the core clock – almost 300MHz higher than the rated turbo clock. This was a trend that we pushed further in overclocking. Using EVGA's Precision XOC, we managed to bump up the core clocks by an additional 155MHz, and the memory by a staggering 500MHz, leaving us with a max core clock of 2,062MHz, and memory at 6GHz, giving us a total of 12Gb/s bandwidth, leading to a 10% improvement in both minimum and average frame rates at 4K, while simultaneously bumping up our Fire Strike figures by almost 2,000 points at 1080p.

All things considered, the GTX 1080 Ti is something of an odd ball. With 11GB of VRAM, and a butchered memory architecture to complement its Frankenstein memory speed, plus that strong overclocking potential, it outperforms a card that essentially costs $570 more, and comes in at the same price that the GTX 1080 cost 10 months ago (that's 50 cents degradation in value per day for the lucky FE owners out there).

That said, it's hard to argue against the computational prowess of this phenomenal GPU.

Zak Storey

Verdict

Features	★★★★★
Performance	★★★★★
Value	★★★½

Solid 4K performance, great overclocking potential and outclasses the Titans. But of course, it's pricey.

★★★★½

INTEL Z270 MOTHERBOARD

$289 | WWW.ASUS.COM/AU

ASUS RoG Strix Z270F Gaming

An alternative formula for gaming.

In last month's APC, we tested the Strix Z270G Gaming – the micro-ATX entry from ASUS's new Strix motherboard lineup. This issue, we have its bigger, full-ATX brother in the labs – the Strix Z270F Gaming. This second Strix board feels like it has a lot in common with ASUS's premium and established RoG Maximus board family. With the Z270G striking similarities to the RoG Maximus Gene, the Z270F does at least have a passing resemblance to a stripped-down Maximus Formula – although that's something ASUS denied when we brought it up in discussions.

That said, regardless of any perceived links within the Maximus and Strix ranges, the Z270F Gaming still presents an interesting option to consider. From an overall design perspective, the Z270F attempts to strike a balance between delivering features orientated towards general performance, gaming and improved aesthetics. And for the most part, it delivers on all three.

Like the Z270G, the Strix Z270F delivers the expected level of performance for this mid-tier of Z270 board. Gaming speed is in line with what we've previously seen, with strong performance shown in our *Far Cry Primal* tests, paired with good overall outcomes on the storage I/O across both SATA 6Gbps and NVMe (PCIe x4) storage protocols.

On the other hand, there are faster Z270 options available. Looking purely at numbers, the Aorus Z270X-Gaming 8 (opposite) is a faster motherboard, but it's also more than twice the price. Bearing that in mind, it's difficult not to give a nod to the effort presented by this more wallet-friendly Strix. And it's perhaps testament to the general high quality of boards on the market today that there is such close competition across a wide price variance – certainly food for thought when considering your PC building budget, and where your resources are allocated.

From an aesthetics perspective, it's difficult not to appreciate the Z270F's subtly muted visual palette, creating a 'less is more' kind of appeal. The lighting options for the motherboard, both direct (RGB LEDs) and indirect (surface reflections) make for a visually intriguing design that can say as much or as little as the user wishes, with lighting finely controllable using the bundled ASUS Aura Lighting software. The unit is rounded out with sleek metal textures, an attractively diffused primary RGB LED lighting feature on the rear I/O shield and two on board RGB headers.

With customisation a key focus for the RGB integration, onboard RGB LED features can be coordinated with a selection of RoG RGB products using the Aura Sync program. Further customisation can also be achieved with mounting points for 3D printed objects – another frontier for PC customisation embraced by the Strix product range.

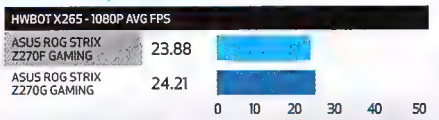
Coming from a pedigree of established performance capability, focused features and reliably intuitive user interaction, the Strix Z270F Gaming presents a strong argument for consideration in your next build spec.

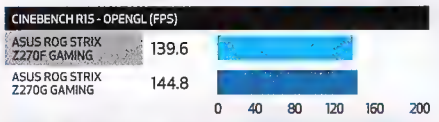
Josh Collins

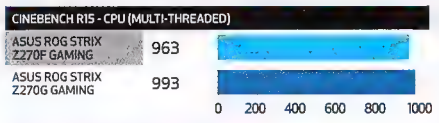
LABS BENCHMARK RESULTS

General system performance

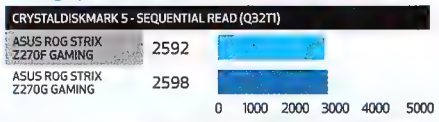
Multimedia performance







Storage performance


CRYSTALDISKMARK 5 - SEQUENTIAL READ (Q32T1)
ASUS ROG STRIX Z270F GAMING 2592
ASUS ROG STRIX Z270G GAMING 2598
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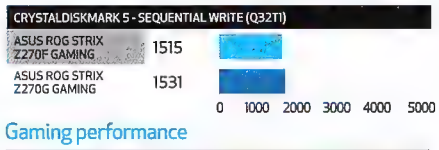
CRYSTALDISKMARK 5 - SEQUENTIAL WRITE (Q32T1)
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ASUS ROG STRIX Z270G GAMING 1531
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Gaming performance

3DMARK (2013) - FIRE STRIKE EXTREME (SCORE)
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ASUS ROG STRIX Z270G GAMING 9481
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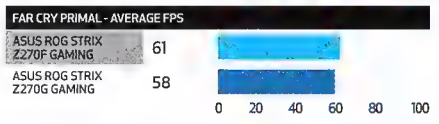


Verdict

Features	★★★★½
Performance	★★★★
Value	★★★½

A well-rounded Z270 option, offering appealing features, performance and aesthetics; a strong contender.

★★★★½

apc RECOMMENDS

INTEL Z270 MOTHERBOARD

$639 | WWW.GIGABYTE.COM.AU

Gigabyte Aorus Z270X-Gaming 8

Core frills to add to the thrills.

A few Aorus motherboards have passed through the labs over recent issues, and this month, the Z270X-Gaming 8 joins the Gaming 9 at the top of Aorus's Z270 stack.

A few core features differentiate the two – namely the motherboard based CPU VRM water-cooling solution, the networking setup, multi-GPU support, as well as smaller changes, such as the Gaming 8 being built to the ATX form factor, whereas the Gaming 9 uses the extended-ATX (EATX) form factor to squeeze in additional components.

The Gaming 8 uses a VRM water-cooling solution branded the Bitspower G-Chill Hybrid Water Block. The Gaming 9, on the other hand, implements a solution by EK Water Blocks – often seen as the king of custom water cooling – in the form of the EKWB G-Frost Hybrid Water Block. In both cases, the cooling solution provided is of very high quality, well implemented and delivers comparable capability.

There are also some key differences between the networking. The components used in the Gaming 9 will be viewed by some as a significant bonus, while others may view them as a deterrent. The positive view of the Gaming 9 is the ability to aggregate the trio of Killer-branded NICs, across two Gigabit Ethernet ports and a 2T2R 802.11ac wireless NIC, meaning you can combine all connections into a single one to maximise potential bandwidth. This requires supporting network hardware at the router/switch end and some configuration to achieve the desired outcome, but it's not a difficult solution to roll out.

Not everyone is a fan of the Killer series of NICs, however. Many prefer the tried and true Intel I219-V NIC you can find on so many other Z270 motherboards – and in that area, the Gaming 8 has you covered.

Splitting the difference, the Gaming 8 still provides twin Killer NICs – the Killer E2500 LAN and Killer Wireless-AC 1535, which can again be aggregated for increased bandwidth via network teaming. However, for the networking diehards Gigabyte's also included a second Gigabit Ethernet port powered by the Intel I219-V chip.

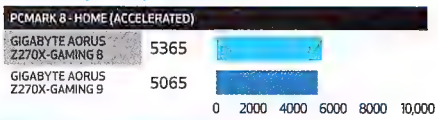
In comparison with the Gaming 9, the Aorus Z270X-Gaming 8 has also cut costs with the choice to reduce SLI support to two-way setups. This meant the removal of the special PLX chip that's used to facilitate the four-way SLI support on the Aorus Z270X-Gaming 9. We welcome this alternative spec implementation as a more practical move for positioning the Gaming 8 into a more palatable price point versus the Gaming 9, with near equivalent specs for the average Z-platform expectations. Because, really, if you're looking at a four-way GPU solution, then Intel's X-platform (i.e. X99 chipset boards) is a far better way to go.

To concisely sum up then, for most high-end users, the Gaming 8 offers a more realistic and practical spec when compared to the Gaming 9. While the latter has extra features, they're ones few people really need.

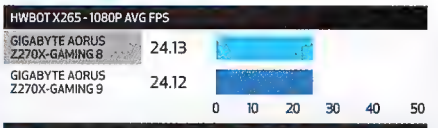
■ Josh Collins

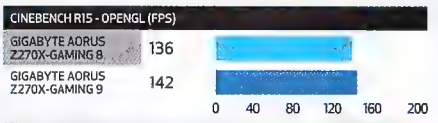
LABS BENCHMARK RESULTS

General system performance

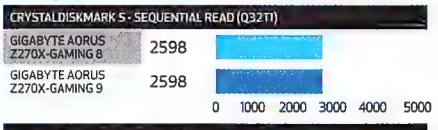


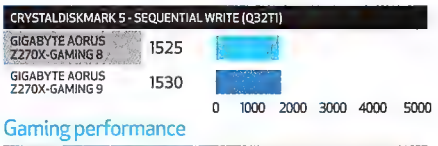
Multimedia performance



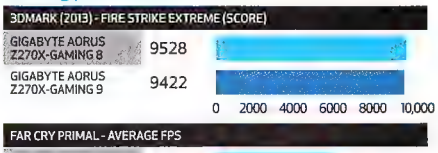


Storage performance





Gaming performance

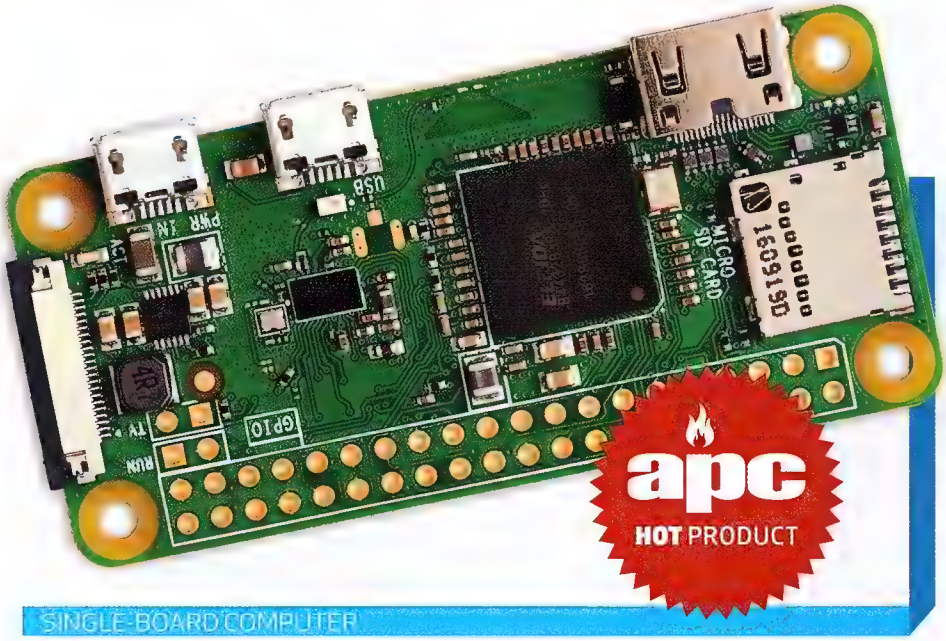


Verdict

Features	★★★★
Performance	★★★★½
Value	★★★½

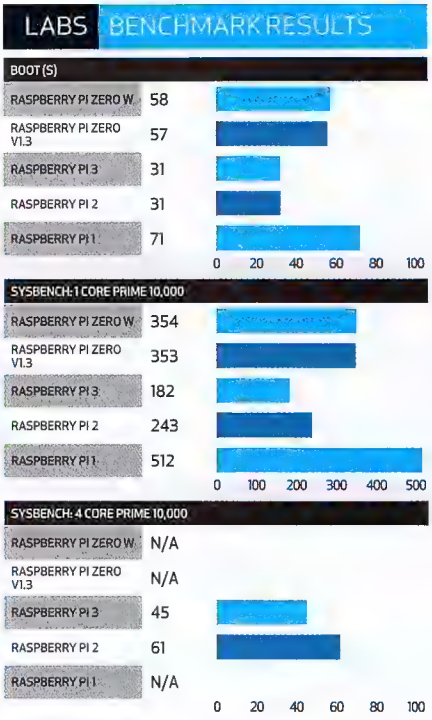
A toned-down version of its brethren, but appropriately reduced in all the right places for a fulfilling solution.

★★★★



SINGLE-BOARD COMPUTER

$26 | WWW.RASPBERRYPI.ORG


LABS BENCHMARK RESULTS
BOOT (S)
RASPBERRY PI ZERO W 58
RASPBERRY PI ZERO V1.3 57
RASPBERRY PI 3 31
RASPBERRY PI 2 31
RASPBERRY PI 1 71
0 20 40 60 80 100
SYSBENCH: 1 CORE PRIME 10,000
RASPBERRY PI ZERO W 354
RASPBERRY PI ZERO V1.3 353
RASPBERRY PI 3 182
RASPBERRY PI 2 243
RASPBERRY PI 1 512
0 100 200 300 400 500
SYSBENCH: 4 CORE PRIME 10,000
RASPBERRY PI ZERO W N/A
RASPBERRY PI ZERO V1.3 N/A
RASPBERRY PI 3 45
RASPBERRY PI 2 61
RASPBERRY PI 1 N/A
0 20 40 60 80 100

Raspberry Pi Zero W

Always hungry for more Pi, this time we get a smaller portion but new features and still with zero calories.

The Pi Zero was a surprise in late 2015. It introduced a new type of Pi, one that eschewed high specifications for a cheaper, smaller board. The original Zero was just missing one thing, but then so was the then-flagship Raspberry Pi 2 – that was wireless connectivity.

With the release of the Pi 3 in early 2016, we saw Wi-Fi and Bluetooth added to the Pi, and now these features have trickled down to the Pi Zero W.

The Pi Zero W is almost identical to the previous models of Zero. It comes with the same camera (CSI) port that was introduced with V1.3 of the Zero and the same unsoldered 40 pin GPIO (General Purpose Input Output) interface to connect your Pi to electronic devices and add-on boards. But the Pi Zero W board layout has changed slightly. The logo is no longer present on the Zero W, and in its place is a small silver chip. This is the BCM4343A wireless package, the same package as found on the Pi 3. But rather than use the same surface mount antenna as the Pi 3, the Zero W has a "resonant cavity" etched into the copper of the board that acts as an antenna. This is licensed technology from Proant. The BCM4343A enables 802.11n Wi-Fi and Bluetooth 4.1, and Bluetooth Low Energy (BLE) for this tiny board, thereby making it ideal for the Internet of Things (IoT).

The market for IoT has seen many different boards, but none with the same level of support as the Raspberry Pi, which has now sold over 12 million units around the world. The Zero W is ideally placed as the entry point for many more people to take their first steps with IoT, and as a sustainable ecosystem for future products.

The Pi Zero W is also a usable desktop machine. It can still be used with LibreOffice, can play 1080p videos and surf the internet. It can also be used in the classroom to teach coding with Python, Ruby and JavaScript.

But the real strength of the Pi Zero W is as a cost-effective embeddable machine that can enable wireless connectivity to projects. By using the Pi Zero W as a headless device, accessed via SSH or a serial console interface, we can access the true power of the Pi Zero W, as a barebones jack-of-all-trades for robotics, nature cameras, and as a sensor processing platform.

The Pi Zero W is also exceptionally power efficient. Eben Upton (the CEO of Raspberry Pi Ltd) said that a 600mA USB power supply is more than ample to power the Pi Zero W, even with active Wi-Fi. Much less than the 2.5A power supply needed for the Raspberry Pi 3.

So what can we expect for $26? A rock solid platform that once again breaks the rules of what a cheap single board computer can do. The Raspberry Pi has been instrumental in bringing down the price of development platforms, and the Pi Zero W does it again. Sure, it may not have a quad-core CPU, 1GB of RAM and lots of USB ports. But what you do get is a cheap platform to build your own projects. And for just $26, you can afford to take a chance and push yourself to make something amazing.

Les Pounder

Verdict

Features	★★★★½
Performance	★★½
Value	★★★★★

Cost effective and well supported. Pick your project and language, but definitely pick up this board.

★★★★★

USB STORAGE DEVICE

$559 | DROBO.COM

Drobo 5C

USB-C storage that can grow to suit your needs and budget.

The major appeal of Drobo's storage devices is the ability to start with two disks installed and add more later to boost capacity whenever suits you. The distinguishing feature of this model is its USB-C port; a USB-A-to-C cable is included, but if your computer has the newer port, you'll need to get an adaptor or replace the cable. Disappointingly, there's just one USB port onboard, whereas some RAID drives we've tested before have included extras and worked as a hub.

Access to the disk bays requires no tools; the front panel is magnetically sealed and easy to detach. The downside is there's no way to lock the panel in place. A sticker on its back tells you about the statuses the lights on the front-right of the drive may take – credit to Drobo for putting it in a sensible place.

Drobo's online guide walks you through inserting 3.5-inch SATA disks into the bays, installing the Drobo Dashboard on your device, and using the app to configure the drive. Some prebuilt RAID drives only accept disks from their own manufacturer; Drobo doesn't make disks, and it shows no favouritism.

Getting set up took us about 10 minutes, and then a good while longer for the two disks we inserted to be initialised. After that, you can add more disks at will; detection takes roughly 10 seconds.

Some of the total capacity of your disks is set aside as an overhead to protect against a disk going bad. With the default settings, one can fail without enduring any data loss. Protection against two disk failures is an option, if you're willing to sacrifice additional space for files. Replace a failed disk with one of the same or a greater capacity and the array is rebuilt automatically for you.

The dynamic nature of Drobo's BeyondRAID tech enables you to expand on the capacity of whatever disks you choose to install in the first place; you can remove one disk and install a new one of a larger capacity without problem. Again, the drive deals with this automatically, saving you some worry.

Drobo's capacity calculator (**bit.ly/2IWT9eE**) is helpful for checking how your particular combination of disks and choice of single- or dual-disk redundancy will affect the space that's actually available for your files, ahead of you buying new disks.

Dashboard shows array and disk status info clearly, and is complemented by a menu bar icon that informs you of problems – a nice touch if you'll put the drive somewhere that results in the status lights on its front being out of sight. As for Time Machine support for Macs, Dashboard provides an option to limit the space it can use by setting aside capacity on a separate volume to your other files.

The Drobo 5C is a great way to consolidate and grow your computer's storage over time. Its port is limited to USB 3.0 speeds, though; the more costly 5D has two Thunderbolt ports, enabling daisychaining and providing more bandwidth, plus it has an mSATA bay to further boost performance with an SSD. However, the 5C's price, setup process, and supporting software make it an affordable and flexible pick for protecting files at home.

Alan Stonebridge

Verdict

Features	★★★★½
Performance	★★★★
Value	★★★★

The 5C offers the usual Drobo benefits, but there's room for a second-gen model to improve on it.

★★★★½

GAMING KEYBOARD

$159.95 | WWW.ROCCAT.ORG/EN-AU

Roccat Isku+ Force FX Gaming Keyboard

Is the world's first pressure-sensitive keyboard a tour de force?

The Roccat Isku+ Force FX is a gaming keyboard with a name that's almost as intense as its feature list. The latter includes plenty of elements that we've previously seen on the German company's other Isku 'boards, plus one potentially game-changing new addition.

The 'Force' part of this membrane-keyboard's name refers to a technology built into its QWEASD keys, which sit on a polymer-piezoelectric composite layer, enabling them to detect varying degrees of pressure. This innovative pressure sensitivity is, as far as we know, a world-first in gaming keyboards and it aims to bridge the gap between analog joysticks on console controllers and the on/off nature of computer keys. Roccat's Swarm config software comes with all the fine-tuning options you need, letting you assign different pressures to keys and key combinations, and there are even some presets for games like *CS:GO*.

The visual feedback provided by the five profile indicator lights helps shorten the learning curve, but despite being able to adjust the specific pressure cut-offs for different actions, the precision needed to operate them accurately will take some seriously adjusting to. Also, all three levels of pressure-triggering won't prove as useful for some games, considering the lowest movement speed (typically when you're sneaking or walking) is often hardwired to a 'toggle' key rather than combination 'hold and move' keys. So while the feature has its uses, it could just as easily become an industry standard as a niche novelty, depending on whether or not the games support it.

Outside of this feature, the Force FX combines the best components of its predecessors to become the apex of the series. The form factor is almost identical to previous iterations, with the same overall bulkiness, but now with an improved 'granular' surface, offering better grip and resistance to smudging. This reviewer found the wrist rest a bit too large to be comfortable, and not having the option to detach it was frustrating.

However, the reason for this is likely the inclusion of the Thumbster macro keys below the Spacebar, providing quick access to profile selection and Roccat Swarm. This software is your control centre, and while, at first, it can be overwhelming, it manages to lay out the multitudinous options intuitively. You can create and manage up to five profiles, each with its own indicator light, that store information on your key assignments, macro settings and RGB colours.

You have16.8 million RGB options to illuminate your keys, with six different brightness settings and a variety of effects. However, the media and utility keys can't be lit, and the soft grey text on the black plastic is very difficult to read.

Aside from this, there is the familiar array of dedicated macro keys as well Roccat's signature Easy-Shift technology, which allows a large zone of keys to have easily accessible secondary functions.

Harry Domanski

Verdict

Features	★★★★½
Performance	★★★★
Value	★★★½

The Force FX's pressure-sensing keys work well when supported, but that support is hit and miss.

★★★★☆

GAMING KEYBOARD

$299 | WWW.RAZERZONE.COM

Razer Blackwidow Chroma V2

Comfy and clicky.

There was once a time when a $300 keyboard would've made us cough and splutter, but these days, the premium end of the gaming board market is littered with similarly-priced units all vying for space.

Razer's first BlackWidow Chroma was a great gaming keyboard, so we were interested to know what had changed. Our test unit came with Razer's own tactile and clicky Green switches, but there's also the option of orange (tactile and silent) or yellow (linear and silent). Another nice addition is the USB charging port and headphone jack on the right-hand side of the board.

The design and layout of the keys have thankfully not changed. These are great under the fingertips – you won't be hitting the wrong keys in a hurry – but that said, we do feel as though the function keys are just a tad too far away to comfortably find quicksave (aka F5) without looking. A minor niggle, perhaps.

There is a bank of four dedicated macro keys down the left. Another similarity is the lighting effects, powered by Razer's Synapse, with 16.8 million colours to choose from. One useful effect is the static per-key templates, useful for *Dota, CS:GO, League of Legends* and *Starcraft II* players, as each has a template. It also caters to default MMO, MOBA, FPS and RTS styles.

The best new thing, though, is the ergonomic wrist rest. Razer has included a magnetic and super comfy cushioned wrist rest that sticks to the original shape of the board, meaning it's optional, effortless to add or remove and doesn't impact on design. Bit pricey, though.

■ Carmel Sealey

Verdict

A few small improvements to an already good board, ensuring its place as a great premium option.

★★★★½

PC CASE

$160 | WWW.BITFENIX.COM

BitFenix Shogun

A Taiwanese case-maker breaks the tempered glass barrier.

BitFenix's desire to innovate in a field that's overcrowded with rectangular boxes has inspired us in ways you could only imagine.

The Shogun is the latest in BitFenix's vast arsenal of case designs. And, boy, is it a beauty! Although it lacks the soft-touch finish of its predecessors, the curved aluminium base and roof panels add an elegance that awes. Couple that with its unfettered airflow access, and it's plain to see why this was such a solid idea.

It features tempered glass side panels down the side of the case. This gives a fantastic edge to the square design, mixing curves with straight lines to form an amazing aesthetic appeal.

The Shogun comes packed with some neat additions, including two side-panel-facing SSD mounts with RGB LED lighting, and three 'GPU Safe' mounts.

Cooling, however, is where the Shogun really shines. Supporting up to three 140mm fans in the front, three 120mm or two 140mm fans in the roof, and one 140mm fan in the rear, the liquid-cooling potential is massive. With additional recessed radiator mounting points embedded into the chassis itself, it makes any liquid or air-cooling setup a reality, with little to no fuss.

Total hard drive support is elegantly covered by the two RGB 2.5-inch mounts on the side, another two on the rear of the motherboard tray, then a further six 3.5-inch drive bays, which can be converted to work with 2.5-inch devices too.

It's hard to argue that the BitFenix Shogun hasn't got everyone's configuration covered here.

■ Zak Storey

Verdict

Solid design, nice features, clean style, angled glass side panels and supreme cooling support.

★★★★½

software

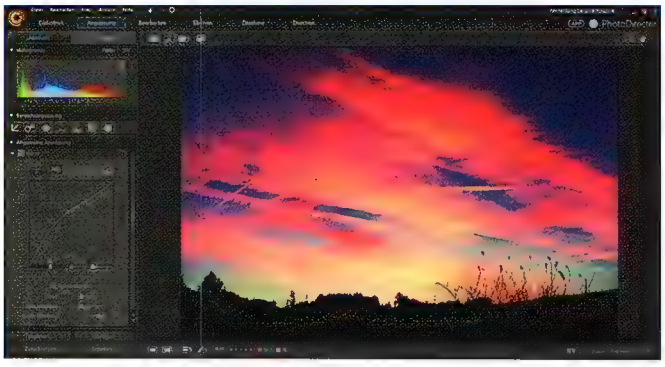
» APPS FOR ALL THE PLATFORMS

Windows SOFTWARE

CyberLink PhotoDirector 8

Much more than just a raw image converter.

$185 | WWW.CYBERLINK.COM



Despite a multimedia and design software landscape that's dominated by Adobe products, a number of smaller devs are still working hard to produce compelling alternatives – and PhotoDirector 8 is a perfect example, pairing powerful pro-level raw image cataloguing and processing with quick and easy effects for beginners.

PhotoDirector 8 is aimed at enthusiast photographers, with tools that provide everything you need to make excellent raw conversions and process JPEGs, TIFFs and PNGs, and the results are so good that there's no reason why the software can't be used by professionals, too.

For beginners, there are a number of manual adjustments offering auto options, plus one-click presets that can be used to apply a range of effects at the touch of a button.

The interface is intuitively laid out, with the main image processing controls on the left. Along the top there are six tabs covering Library, Adjustment, Edit, Layers, Slideshow and Print, all of which are fairly self-explanatory.

If you're familiar with Lightroom, you'll notice the two programs aren't a million miles apart. The main image window offers a selection of viewing modes, allowing you to choose what's most convenient for photo browsing or image processing.

The overall user experience is similar to that of Lightroom, but the main difference with PhotoDirector is that there are layers which can be used in a number of ways, including for making image adjustments, creating montages and adding text. They're not as versatile as layers in Photoshop, but they do help to create a bridge between raw processing and standard image editing, and you can complete many (or often all) of your edits in PhotoDirector.

PhotoDirector 8 is an attractive and powerful software option that comes at an affordable price for the Ultra version. This is a one-off licence fee, so there's no subscription involved – something that will be welcomed by photographers reluctant to sign up for services such as Adobe's Photoshop CC. **James Abbott**

Open Broadcaster Software

Easily the best free screen recorder for capturing or streaming gameplay.

FREE | TINYURL.COM/APC441-OBS

Unlike the hugely popular free screen recorder FRAPS — which only lets you record for 30 seconds without buying a licence and applies a watermark to the resulting footage — Open Broadcast Software (OBS) is open source and completely free to use without restrictions.

It supports both streaming and recording in high definition, with no restrictions on the number of uploads or the length of your clips. You can stream live to Twitch or YouTube gaming, save projects and come back to them later, or encode your footage in FLV format and save it locally.

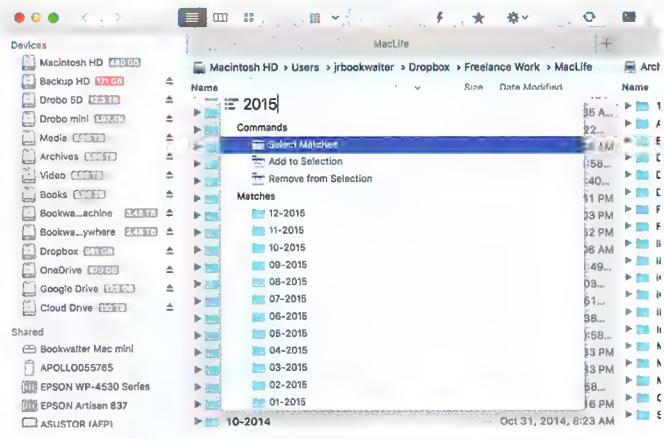
Because OBS can record directly from your graphics card, it's able to capture games running in full-screen mode (many other screen recorders can only record if the game is windowed), with customisable hotkeys to control the recording. OBS can also make full use of multi-core CPUs for improved performance, and can record at 60fps or even higher.

It might take a little while to set it up, but OBS is by far the best and most powerful free screen recorder for gamers we've encountered. **Cat Ellis**

ForkLift 3

Heavy lifting for your file management.

US$30 | BINARYNIGHTS.COM



Just because something has been around a long time doesn't necessarily mean it's good. Case in point: Finder, the venerable Mac file manager which, after more than three decades, remains a core part of the macOS experience, but which hasn't really changed in its basic operation for most of that time. Although Finder isn't likely to go away anytime soon, there's always room for welcome improvement.

ForkLift 3 is a Mac app that serves double duty as a full-featured alternative to Finder, as well as a client for transferring files between local and remote FTP, WebDAV, Amazon S3 or other connections. ForkLift offers many advantages over Finder, not the least of which is the dual-pane interface that makes copying and moving files or folders between two different volumes a breeze. Like Finder, ForkLift also offers single-pane and tabbed window views as well.

To alleviate some of the complexity inherent in third-party file managers, ForkLift 3 introduces Quick Open, a mouse-free feature invoked by pressing Esc and then typing a few letters of the location or command you're looking for. Keyboard jockeys will also embrace Quick Select, which intelligently prunes a large list of items by using a Command-S shortcut to select, add or remove searched files and folders from the current selection.

Among our favourite new features are the ability to make quick revisions to text files directly in the right-hand preview pane — no text-editing app required! — and bulk-rename files using a variety of prefixes, suffixes, padding and sequential numbering options. This is a task we've traditionally relied on A Better File Rename to conquer, but having this functionality baked into ForkLift means less hopping between apps. Even better, you can save frequently-used settings as a preset, which can be added to the sidebar for super-fast drag-and-drop access in the future.

ForkLift is also ready to serve when the app isn't running courtesy of ForkLift Mini, a menu bar icon from which you can mount saved remote connections as desktop volumes, perform drag-and-drop transfers by opening droplets, and run saved 'synclets' to synchronise files between local and remote targets. Finally, ForkLift now sports a slick optional dark mode, and overall feels much snappier than the previous version.

This iteration is faster and more versatile than ever, ForkLift 3 is a winning update to the premier Mac file manager and FTP client. **J.R. Bookwalter**

ReadKit

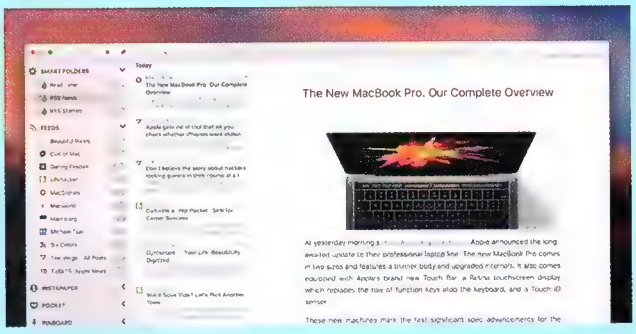
The king of aggregators.

$14.99 | READKITAPP.COM

Between Instapaper, Pocket, Pinboard, and a variety of RSS sources, Mac users can wind up bouncing between multiple applications to get caught up with news subscriptions. ReadKit unites these disparate services under the same roof, providing a single destination for all your news.

In addition to those services, ReadKit includes its own offline RSS engine for new or imported OPML feeds, but also syncs with popular providers Feedly, Fever, NewsBlur, Feed Wrangler and Feedbin. Some need a premium subscription to work, but free accounts are often all right.

The beauty of having everything under one roof is that you can drag and drop articles, bookmarks or feed stories between different services with ease. Feeds are grouped by account in a sidebar, with a unified Smart Folders inbox that sorts unread content into predefined categories of your own choosing. There's complete customisation over everything, including the toolbar buttons, font style and page width. There are four light/dark colour themes and full articles can be read in a clean, text-only view.



This may be the one Mac reader to rule them all — but where's the iOS version? **J.R. Bookwalter**

Linea

A great sketching tool for the Apple Pencil.

$14.99 | LINEA-APP.COM

The iPad is already home to a variety of powerful sketching and painting apps, but Linea is somewhat different. It's designed to give you just enough in the way of tools to capture your ideas, without overwhelming you with a complex selection that you'll never use.

Though the iPad's smooth surface can't truly mimic drawing on paper, you'll soon get a feel for Linea's responses to pressure and the angle of your Apple Pencil, and then turn those into convincing lines using its technical and drawing pencils, felt tip pen and wide tip marker. Where some apps translate pressure to line thickness, Linea more naturally binds it to the darkness of what you draw, and the side of the Pencil's nib can be used for shading.

As with many other apps, you can twist two fingers on the digital paper to turn it, and double-tapping the lock icon fixes its orientation so your palm doesn't move it. As your Pencil approaches a toolbar, the interface disappears so you can continue your movement unbroken. Each tool has three thickness settings, and you can spread apart two fingers to zoom in if you need to focus on fine detail or fixes.

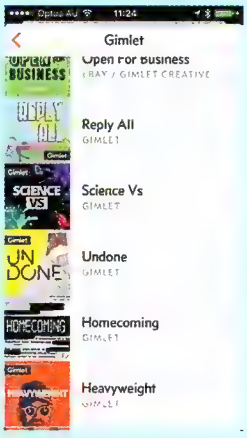
You get five layers to work on, which can be merged if needed. We found this limitation imposed a helpful formality on our process. Layer opacities can be adjusted using tiny sliders – designed with Pencil in mind, yet still too small for comfort. Linea's focus on the basics mostly works, though a ruler and a compass to enable precise lines and circles to be drawn would be a welcome addition.

This is a natural-feeling sketching app, with room to grow while keeping its simple appeal. **Alan Stonebridge**

Overcast

Podcasts at your fingertips.

FREE WITH IAP | OVERCAST.FM

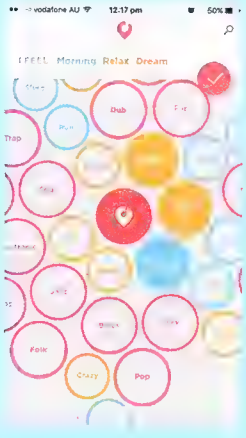


Overcast has recently had a makeover. This popular iOS podcast hub has a simple search function that turns up a seemingly endless number of productions. The user interface is simple, clean and easy to navigate, but after its 3.0 update recently, it's even better. Importantly, the Now Playing view has been redesigned, allowing you to swipe left for more info on that episode and swipe right to adjust the volume settings. Another thing that's changed is that your Now Playing, settings, recommendations and downloads screens now adopt stacks, so they slide up from the bottom of the screen. You can now access options for episodes more quickly by tapping on one in a list, giving you the option to share, add to queue, delete or play. There's a new widget for the home screen to play with and new 3D touch abilities give you quick access to episode contents. Another welcome addition is the new design of the Watch companion app and the ability to now view what's next in your queue. This is still our favourite third-party podcast app for iOS. **Carmel Sealey**

SoundR

Spotify, you've got competition.

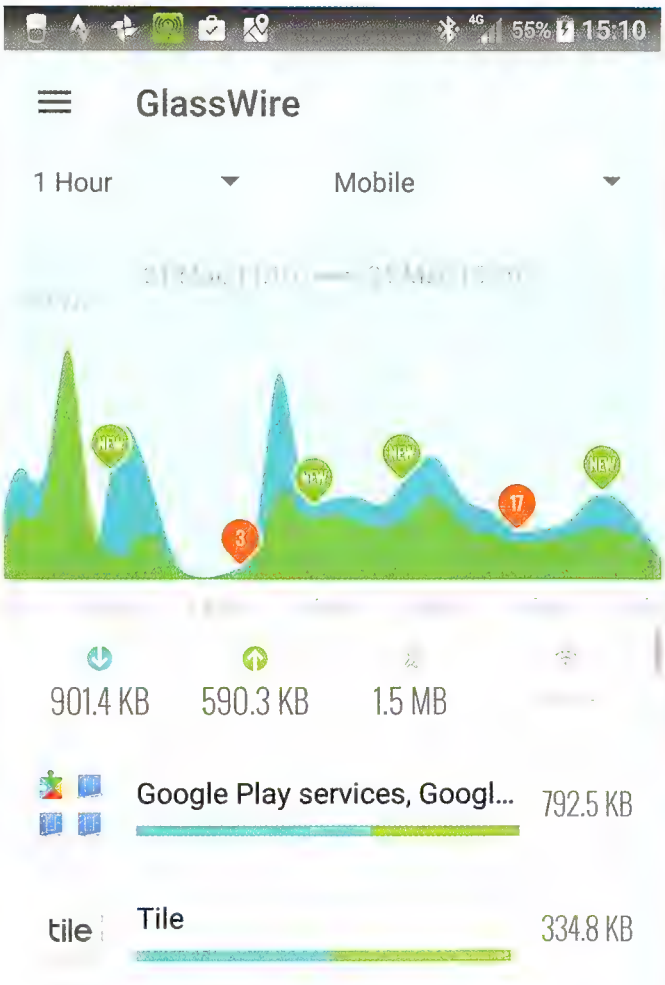
FREE | SOUNDR.FR/EN/INDEX.HTML



While most music streaming services like Spotify and Apple Music allow users to discover new music according to genre or activity, this new app finds you tunes to suit your emotions.

SoundR helps you find music based on genre, activity and feelings — just choose from the fun, colourful floating bubbles in the app's home page (up to four options) and you get the choice of a few playlists relating to your choices. One playlist begins to play automatically, but you can choose another if you want. If you like any playlist, you can save it to your 'favourites'. What you can't do is create your own customised playlist, like in Spotify.

This no-bells-and-whistles app has a refreshingly clean interface, is free, with no interrupting ads. But navigating the emotion bubbles is a tad difficult and the playlists don't begin playing instantly. The library may not be as extensive as the major streaming services, but some of the playlists are pretty darn good. **Sharmishta Sarkar**



GlassWire

Keeping track of all your bits.

FREE | WWW.GLASSWIRE.COM/DOWNLOAD

Anyone racing through their mobile phone data and frustrated with Android's in-built bare-bones management tool needs GlassWire. A simple-to-read graph shows how much your apps are uploading and downloading, from the last 5 minutes to the previous 90 days, and the app pushes out alert notifications when you're close to your data allowance or have blown straight past it. While Android OS offers an idea of the amount of data an app has used, you still have to go through each individual program after digging through the settings menu. Here, everything's linked and you can fine-tune your stats, separating them via mobile and wi-fi usage. Powerful stuff, and best of all – it's free. Incredibly, we haven't noticed any intrusive ads. Even if you're curious about what your apps are up to – thanks to the surprising amount of permissions they have – when you're not actively using them, GlassWire is a must-try. **Paul Taylor**

Energy Bar

Completely superfluous but kinda nice battery meter replacement.

FREE | TINYURL.COM/TLA63-ENERGY

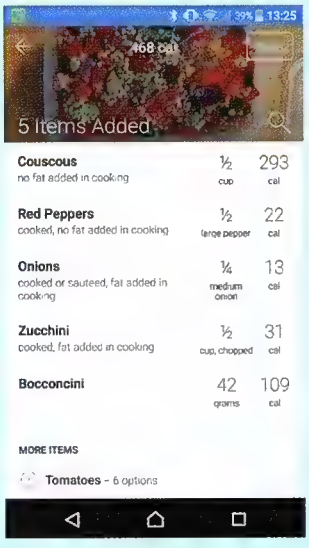
Some people are very fanatical about their phone's battery life, daring not to leave the house unless the little battery icon is satisfactorily full. Energy Bar will presumably appeal to those among us who incessantly monitor their remaining lifeline, as it creates a small colour-coded bar at the top of the Android screen indicating both how much charge is left and, if your phone is plugged in, at what rate it's charging. You could probably chalk this app up as yet another useless-app-that-offers-functionality-you-already-have, and to be honest, aside from aesthetics and some more minor (and rather vague) graphical information, that's exactly what it is. It's nice to know how much your phone has charged since you plugged it in, and at roughly what rate it's charging, but that's about where the novelty ends. There's a ton of different animations you can choose between for the Energy Bar, and the colours can be personalised to suit whatever fancy home screen you've got set. No doubt a useful app for the battery-oriented anal retentive, but hardly a must have. **Shaun Prescott**

Bitesnap | in beta

Calorie-o-graph.

FREE | GETBITESNAP.COM

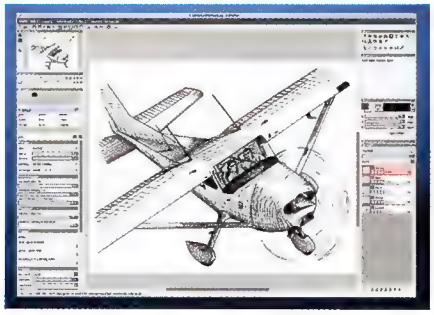
Bitesnap does something different to standard calorie counting apps in that it estimates your energy intake based on a photo of your meal or snack. The theory is excellent: remove boring data input by relying on a visual medium. Anyone who takes artsy photos of their food is one step ahead. Bitesnap asks for your height, weight, age, weight goals and levels of activity and spits out a Body Mass Index, a rough number that indicates whether you're in a healthy weight range or not. (Don't put too much stock into that number, there are plenty of athletic people who are technically overweight.) You're then allocated a recommended amount of calories with macronutrient (carbs, fat and protein) proportions. It's a great theory, though there's a lot of room for improvement, and we acknowledge Bitesnap is in beta. It struggles with recognising complicated meals, meaning you spend a lot of time manually entering the types of food and quantities, which negates the point of the whole thing. **Paul Taylor**



AzPainter

A tiny image editor with big potential.

FREE | BIT.LY/2M2WQPN



The hero of this month's Linux apps is this tiny program, the source code of which occupies only half of an old-fashioned 3.5-inch floppy disk, or as little as 750KB. Yet it also poses a challenge to major image editors such as Gimp or Krita – the heavy-weight Linux apps for graphic enthusiasts and artists.

AzPainter is for drawing bitmap illustrations. It implements an original UI layout optimised for efficient drawing workflow. The application features support for 16-bit colour images with transparency (RGBA), automatic brush size adjustment depending on tablet pen pressure, Photoshop-style layers, dozens of artistic filters, various selection tools, support for many third-party image formats including PSD, and more. And this program packs all these features into a tiny package that also boasts astonishing speed in everything it does, from start time to general responsiveness. We think that there's hardly anything on Earth that contradicts to the term 'bloatware' more than AzPainter.

The application makes use of an original graphic toolkit called Mlib, which is super lightweight. It looks very compact, greyish and, of course, unobtrusive to help you concentrate on the content. AzPainter is very strong at drawing complex shapes and artistic painting, it has numerous brush settings (pressure, blend mode, interval, randomness and other such things), support for textures and lots of extra goodies here and there once you understand the interface.

There are very few AzPainter binaries on the internet and the official AzPainter home page is in the author's native Japanese, making it slightly harder to get the application running on your system. However, building it from source doesn't require many dependencies, and the process goes swiftly using the good old `./configure && make && sudo make install` sequence.

Alexander Tolstoy

KSnip

Scissors, scissors, screen!

FREE | BIT.LY/2MMADRT

Almost all Linux users want to populate their desktops with small, handy accessories that make everyday life easier. Windows' standard snipping tool accomplishes the built-in system screenshot-taking feature, usually bound to the Printscreen button. Although you can slightly customise its behaviour, all other useful features, such as drawing arrows over a grabbed picture, are only available in snipping tools or third-party commercial apps. Remarkably, Linux desktops still lack out-of-the-box snipping tools.

KSnip is a clone of the Windows snipping tool — a compact floating always-on-top window, which lets you grab a custom part of the screen and quickly emphasise something in it. You can draw lines, rectangles, ellipses or use the highlighter in a non-destructive way: everything is superimposed over the image and you can always move or delete any drawn object. There is no arrow tool right now, but you can draw straight lines by holding down Shift and using the Pen tool. The Ksnip settings window hides default drawing colours and also the very useful Imgur uploader (authentication is supported).

Ksnip is currently in active development. When we first came across this, it didn't have rectangle or ellipse drawing tools, so you can bet that there's more still to come.

For some reason, the code sticks to the legacy Qt 4.8 version, however, and also needs GCC 4.8 for successful compilation. The KSnip developer expressed hope for porting his app to Qt 5 in the mid term, but it will require significant code refactoring.

Alexander Tolstoy

Buttercup

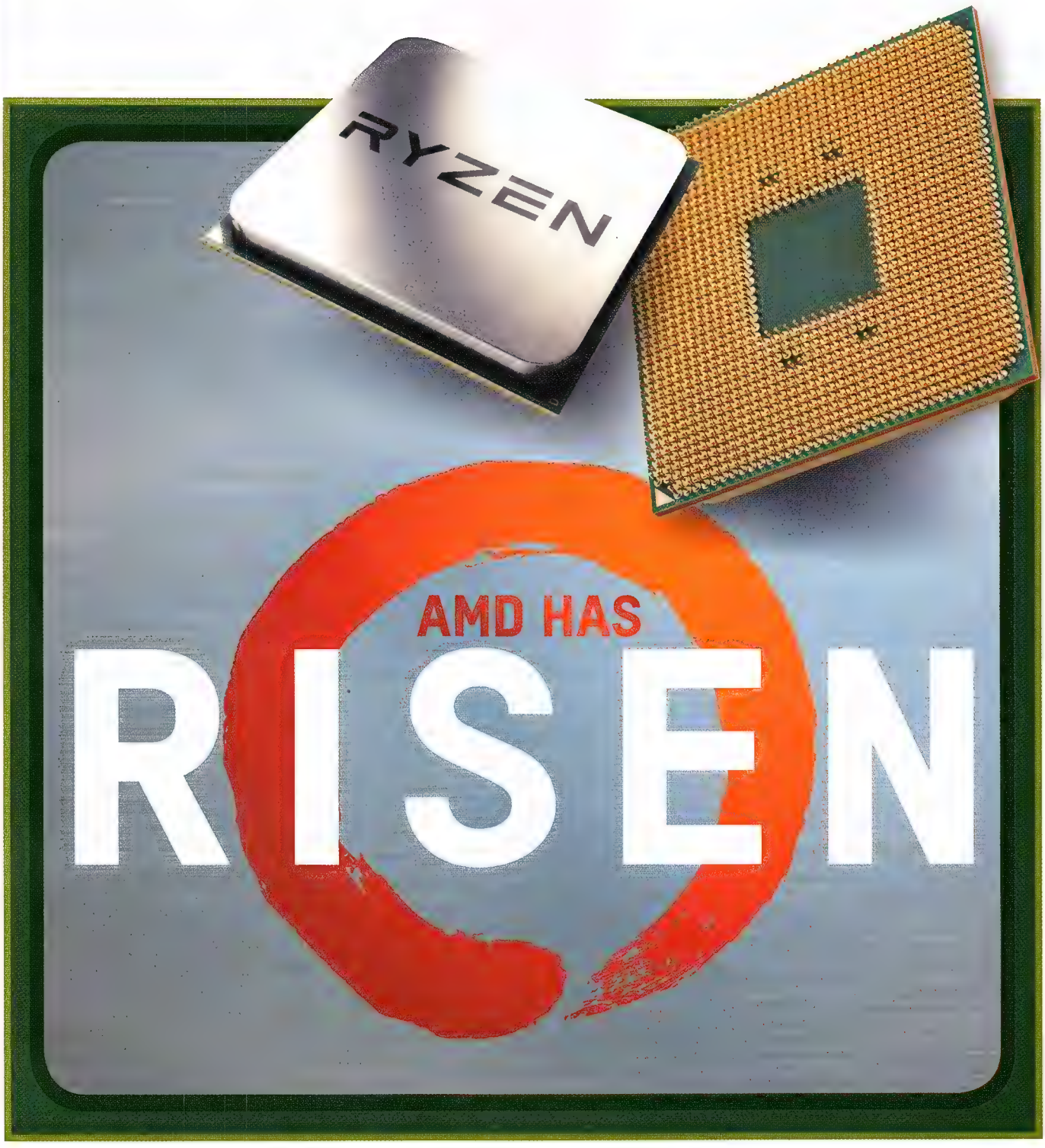
Manage your passwords here.

FREE | GITHUB.COM/BUTTERCUP-PW

Buttercup is a password manager that tries to maintain a very high security level without burdening the user with complexities. It's a nice-looking JavaScript-based application that offers you a convenient interface for organising your passwords in a sort of vault, protected by a master password. Each vault is referred to as an 'archive' in Buttercup, and you can have as many archives as you like. Inside each archive, you are free to create a tree structure of categories and populate them with entries. Buttercup lets you save tips and extra memos together with names and passwords — it is possible to add any number of custom fields to an entry. If the application detects a weak password, it shows the appropriate notification. The 'magic wand' icon to the right of the password input fields puts a pop-up password generator with advanced settings at your fingertips.

Buttercup is accompanied by the same-named browser extension for Chrome and Chromium, which means that you don't need to manually copy-paste your credentials from the desktop application to the browser. Technically, Chrome and Chromium (and most other web browsers) provide the same functionality out of the box, but you may want to use a third-party password manager provider if you trust it better. Buttercup seems to be a very reliable replacement for built-in password managers thanks to its advanced features, such as search, rubbish bin, password generator and more.

The whole solution is very safe: the archive, upon saving, is encrypted with AES 256bit CBC mode with a SHA256 HMAC. Encryption is performed once the password has been salted and prepared with PBKDF2 at 1,000 iterations. That's secure. **Alexander Tolstoy**



AFTER MORE THAN HALF A DECADE IN THE WILDERNESS, AMD HAS RETURNED WITH NEW CPUs THAT AIM TO TACKLE INTEL'S BEST

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AMD HAS RISEN
AMD's clawed its way back into the premium CPU market with its new Ryzen processors — but are its new 8-core wonders ready for the brutality of primetime?

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AMD RYZEN 7 1700X
The Goldilocks of AMD's new Ryzen CPU range?

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AMD RYZEN 7 1700
Is this the new ruler of the value performance realm?

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AMD AM4 MOTHERBOARDS
We compare seven brand-new boards from the major vendors.

52
BUILD YOUR OWN RYZEN PC
Budget? No, it's certainly not that — this is our AMD-powered, plug-and-play, rendering titan.

AMD HAS RISEN

AMD'S CLAWED ITS WAY BACK INTO THE PREMIUM CPU MARKET WITH ITS NEW RYZEN PROCESSORS — BUT ARE ITS NEW 8-CORE WONDERS READY FOR THE BRUTALITY OF PRIMETIME? JOSH COLLINS INVESTIGATES.

"Welcome back!" That's the general feeling that's been flowing from the enthusiast community towards AMD with the launch of its new Ryzen CPUs. Based on chip-maker's Zen microarchitecture, Ryzen's been paired with the equally new AM4 platform, utilising a range of chipsets. But it's been a long while since AMD had a CPU of this calibre, so let's rewind a bit. Perhaps, even a byte.

THE LONG TEASE

In case you've been living in the woods with no internet for the past two years, or perhaps you don't follow the speculative PC enthusiast news game very much, by this stage, you have no doubt at least heard or read about AMD's new Zen microarchitecture, in development for several years. Now, after much waiting and anticipation, the products have finally landed: a new range of CPUs and a swathe of motherboard chipsets.

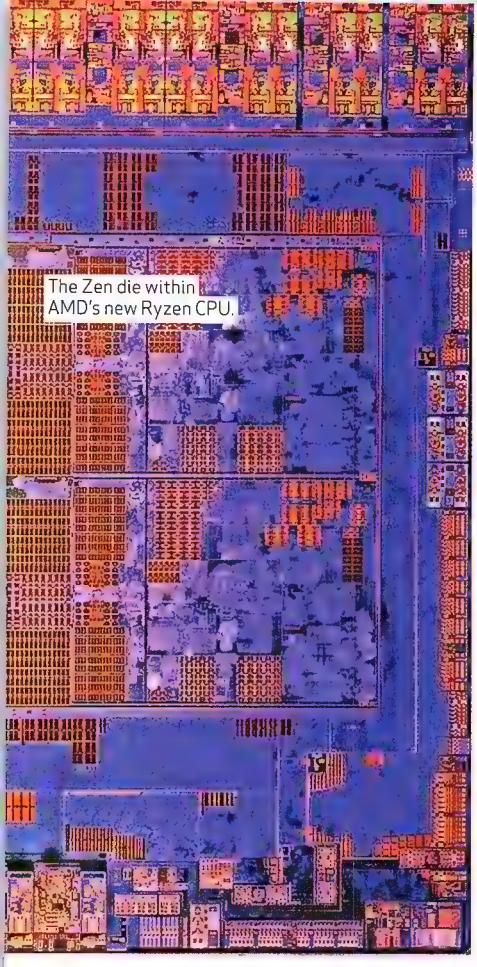
Zen is AMD's first new microarchitecture in five years. Furthermore, the design is a clean sheet design, deriving no inherent values from previous microarchitectures from the company.

This launch is centred primarily around the introduction of AMD's new top-of-the-line CPU range called Ryzen 7, spearheaded by the Ryzen 7 1800X, and five new chipsets covering the needs of enthusiasts, business, consumers and even small form factor specific solutions. These new chipsets

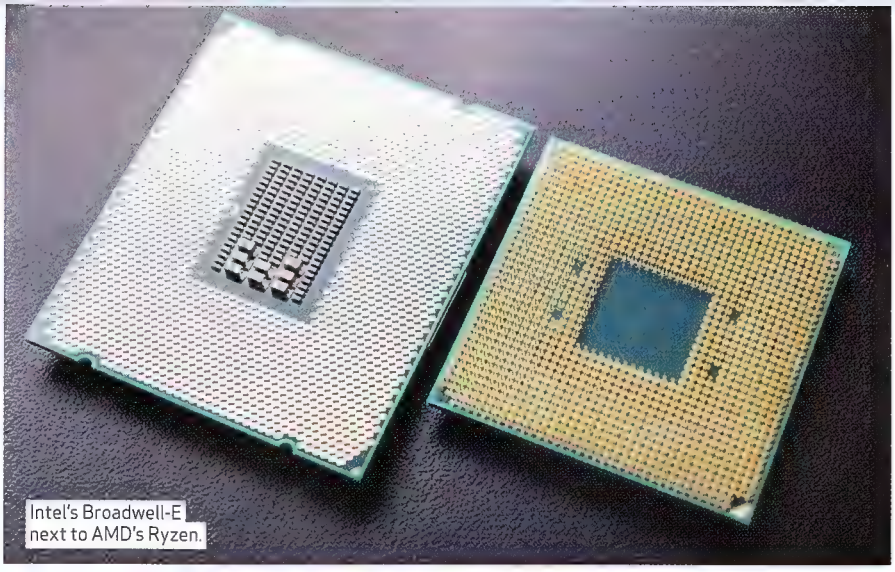
The precious cargo in hand and ready for torture... *ahem* ...testing.

AMD'S CURRENT RYZEN CPU LINE-UP

MODEL NAME	RYZEN 7 1800X	RYZEN 7 1700X	RYZEN 7 1700	RYZEN 5 1600X	RYZEN 5 1600	RYZEN 5 1500X	RYZEN 5 1400
USD RELEASE PRICE	$499	$399	$329	$249	$219	$189	$169
BASE CLOCK FREQUENCY	3.6GHZ	3.4GHZ	3.0GHZ	3.6GHZ	3.2GHZ	3.5GHZ	3.2GHZ
MAX. TURBO CORE SPEED	4.0GHZ	3.8GHZ	3.7GHZ	4.0GHZ	3.6GHZ	3.7GHZ	3.4GHZ
EXTENDED FREQUENCY RANGE (XFR)	4.1GHZ	3.9GHZ	3.75GHZ	4.1GHZ	3.7GHZ	3.9GHZ	3.45GHZ
XFR BOOST FREQUENCY	100MHZ	100MHZ	50MHZ	100MHZ	100MHZ	200MHZ	50MHZ
TDP	95W	95W	65W	95W	65W	65W	64W
CORES	8	8	8	6	6	4	4
THREADS	16	16	16	12	12	8	8
UNLOCKED MULTIPLIER	YES	YES	YES	YES	YES	YES	YES
TOTAL L3 CACHE	16MB (2X8MB)	16MB (2X8MB)	16MB (2X8MB)	16MB (2X8MB)	16MB (2X8MB)	16MB (2X8MB)	8MB (1X8MB)
SOCKET	AM4	AM4	AM4	AM4	AM4	AM4	AM4
FABRICATION PROCESS	14NM	14NM	14NM	14NM	14NM	14NM	14NM
MEMORY TYPE	DDR4	DDR4	DDR4	DDR4	DDR4	DDR4	DDR4
MEMORY CHANNELS	2	2	2	2	2	2	2
BUNDLED COOLER	N/A	N/A	WRAITH SPIRE	N/A	WRAITH SPIRE	WRAITH SPIRE	WRAITH STEALTH



The Zen die within AMD's new Ryzen CPU.



Intel's Broadwell-E next to AMD's Ryzen.

AMD'S AM4 CHIPSETS COMPARED

CHIPSET MODEL	X370	B350	A320	X300	A300
USER CLASS DEFINED BY AMD	ENTHUSIAST	MAINSTREAM	ESSENTIAL	ENTHUSIAST SFF	ESSENTIAL SFF
OVERCLOCKING SUPPORT	YES	YES	NO	YES	NO
PRIMARY GPU VIA DIRECT CPU PCIE	YES	YES	YES	YES	YES
PCIE 3.0 GRAPHICS*	1X16/2X8	1X16	1X16	1X16/2X8	1X16
MULTI-GPU SUPPORT (PCI BIFURCATION)	YES	NO	NO	YES	NO
SATA3 (6GB/S) SUPPORT	CHIPSET NATIVE	CHIPSET NATIVE	CHIPSET NATIVE	CHIPSET NATIVE	CHIPSET NATIVE
SATA EXPRESS SUPPORT	YES - 2	YES - 2	YES - 2	YES - 1	YES - 1
NATIVE USB 3.1 GEN 2(10GB/S) SUPPORT	2	2	1	0	0
NATIVE USB 3.0 / 3.1 GEN 1 (5GB/S) SUPPORT	10	6	6	4	4
NATIVE USB 2.0 SUPPORT	6	6	6	0	0
SATA + NVME SUPPORT*	6 SATA3 + 1 X2 NVME 4 SATA3 + 1 X4 NVME*	4 SATA3 + 1 X2 NVME 2 SATA3 + 1 X4 NVME*	4 SATA3 + 1 X2 NVME 2 SATA3 + 1 X4 NVME*	2 SATA3 + 1 X2 NVME 1 X4 NVME*	2 SATA3 + 1 X2 NVME 1 X4 NVME*
SATA RAID	0, 1, 10	0, 1, 10	0, 1, 10	0, 1	0, 1
MAX. JEDEC DRAM FREQUENCY	DDR4-2666	DDR4-2666	DDR4-2666	DDR4-2666	DDR4-2666
INTEL COMPETITOR CHIPSET	Z270 / Z170 / Q270 / Q170	B250 / B150	H210 / H110	NO EQUIVALENT	NO EQUIVALENT

*NOTE: SOME DETAILS ARE SPECIFIC TO USE WITH A RYZEN CPU, AND DIFFERS TO USAGE WITH A ZEN BASED A-SERIES APU OR ATHLON CPU.

are the X370, B350, A320, X300 and A300. The roundup following this piece covers an offering of X370 and B350 based motherboards. For a breakdown of chipset features, check out the table we've prepared comparing the feature support across the new range.

The new CPU microarchitecture, Zen, is the brainchild of an AMD luminary and chip guru, Jim Keller, backed by his engineering team.

THE PATH TO RECOVERY

The last time AMD had a wholly competitive processor range it was the early 2000s and AMD was giving the blue giant, Intel, a run for its money with its highly efficient Athlon (codenamed K7) and Athlon-64 (K8) processors. There's no surprise, then, when you link the dots to find Jim Keller worked on the Athlon design and was the lead architect for Athlon-64, including co-authoring the specs for the x86-64 instruction set widely used for 64-bit processing on x86 based architectures – even Intel use this.

After the K8 generation, Jim Keller moved on to work for other chip manufacturers such as Broadcomm and Apple, contributing to a range of devices, including the Apple A4 and A5 'system on a chip' (SoC) designs.

The microarchitecture prior to Zen was Bulldozer and saw three revisions in the form of Piledriver, Steamroller and Excavator. All iterations failed to impress against the ever strengthening and evolving Core microarchitecture from Intel. For quite some time, the performance CPU market was a one-horse race, with AMD relegated to the entry-level market.

News broke in 2012 of Keller leaving Apple and resuming a role within AMD, tasked with developing a new generation microarchitecture from a clean sheet. The industry felt an instant buzz. Could AMD return to challenge Intel, which by now had grown to enjoy its market perceived position as CPU leader with minimal competition? We all wanted answers.

For three years, Keller and his team developed the new architecture, followed by 18–24 months of refinement. Though Keller left AMD again in 2015 for new opportunities at Tesla, it wasn't before having laid the Zen groundwork. As such, we can be sure the roadmap will continue to be paved in Zen, just as Intel has tweaked its Core microarchitecture since its launch of the Core i7 in 2008, codenamed Nehalem.

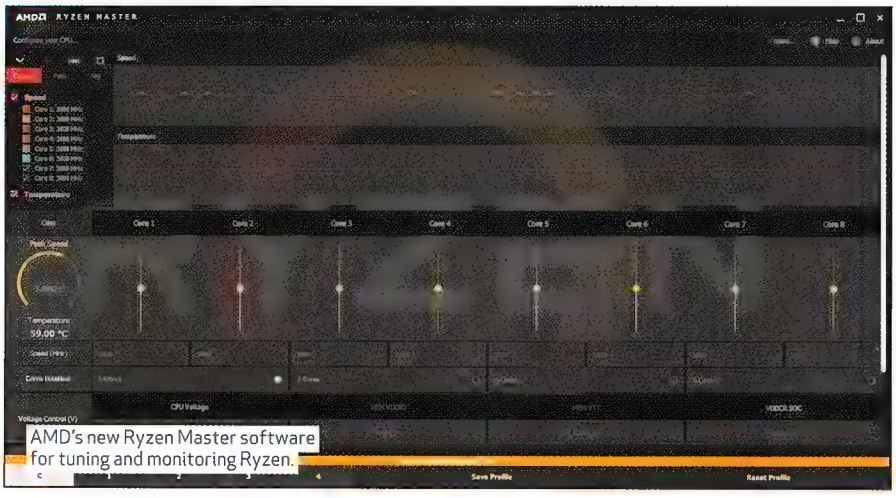
A CLEAN SHEET

With a clean sheet from which to derive AMD's future in the x86 microprocessor industry, there was a formidable task ahead of Keller and his team. A whole new CPU microarchitecture, starting from scratch, is no easy feat and to deliver a solution that not only closed a very considerable performance gap between AMD and Intel but to try to deliver it as quickly as possible can only be summarised as a mammoth task.

While abandoning AMD's previous processors increased the work to be done, it equally removed constraints from the development programme. As such, Keller was free to consider how the CPU would operate and interact with other sub-systems within the platform, along with the current and future needs of a broad range of users and usage scenarios. Essentially, a scalable solution would be ideal, paired with numerous integrated features.

Keller was instrumental in the development of SoC processor designs for Apple. Notably, the Apple A4 and A5 development lead by Keller and found in products like the iPhone 4 and 4S. Therefore, it's not unusual to see one of the significant core differences between Zen based CPUs and its predecessors is the implementation of a SoC design.

This approach encouraged an outcome that would deliver a power-efficient and scalable processor with increased interconnect bandwidth for platform sub-systems. Paired with an efficient core processing capability and the subsequent processor microarchitecture has already left a noticeable impression at launch.



AMD's new Ryzen Master software for tuning and monitoring Ryzen.

A CAUSE FOR DISRUPTION

Based on a SoC design, the controllers for memory, PCI Express, SATA and USB sub-systems are all incorporated into the same package as the processor cores. This introduces increased bandwidth between sub-systems and improved power efficiency. However, this occurs at the cost of creating a significantly more complex chip and impacting die area availability.

The SoC design provides flexibility for adaptation across a variety of uses from mobile to small factors, desktops to servers. This scalability also provides flexibility in how the SoC can be integrated into different platforms with varying goals. For example, the same technology can be used to create a fully featured small form factor (SFF) solution while also providing the backbone for a multi-CPU scaling server cluster. Add simultaneous multi-threading and it's like icing on a cake.

The disruptive nature of the Zen platform isn't just through design. AMD has aggressively targeted Intel in an effort to not only regain market share but to also regain lost mind share. With the AMD Ryzen 7 1800X and AM4 X370 solution poised to do battle head-on with Intel's established Core i7 6900K and X99 platform, performance alone wouldn't be enough. Smart planning has seen the Ryzen 7 1800X enter the market at nearly half the price of the Core i7 6900K and with supporting motherboards on average significantly cheaper. The challenge has been made.

RYZEN 7 1800X AND AM4 TESTED

Our scope of attack was to first assess stock performance. This meant stock CPU frequencies, stock platform frequencies (no bus adjustments) and the vendor referenced, JEDEC backed, stock RAM frequency. In a nutshell, this saw the Ryzen 7 1800X operating predominantly between 3.6–3.7GHz with spikes to 4.0GHz and memory running at DDR4-2666. This setup went head-to-head with numerous Intel CPUs from both the Z- and X-platform and operating with DDR4-2400 RAM.

The Core i7 7700K consistently boosted to 4.5GHz and the Core i7 6900K and 6950X both at stock frequencies and boosting to 4.0GHz. The X-platform provided the most comparable stage for assessing the 1800X, even more so when we re-ran tests with the 1800X overclocked and locked to 4.0GHz.

The 7700K delivered the highest level of gaming performance. However, upon closer inspection, the gap to the 1800X wasn't as big as expected and demonstrated that if AMD can refine the design to increase overall clock speeds of Ryzen, then a hidden strength could be revealed. As expected, the 7700K was cut down in Cinebench, yet held its own in the X265 encoding benchmark.

The Ryzen CPU went toe-to-toe with the X-platform offerings, and while it wasn't the outright fastest of the bunch, what the 1800X did do was embarrass the price point of the Intel offerings. To put this into perspective, a 6900K plus X99 motherboard will cost twice as much for the equivalent 1800X plus X370 motherboard. We hope you're sitting down for this next one: you could build a whole Ryzen PC for the price of the Core i7 6950X alone, much less a motherboard to match it. This is what defines the Ryzen release. For most enthusiasts, an AMD platform wasn't up for consideration. Now, however...

The second course of enquiry set out to observe the same scenarios but with increased memory frequency, with operational frequencies between DDR4-3000 and DDR4-3200. This is when Ryzen started to falter. Initially just reaching DDR4-2933 or DDR4-3200 – native memory frequencies for Ryzen – was a nightmare, but towards the end of the assessment period, we got DDR4-3200, but stability was sketchy.

This demonstrates that AMD's new platform has some teething issues as it settles into the marketplace. We expected this and it was reminiscent of Intel's big shift from Core 2 Quad-X48 to Core i7-X58. It also shows that AMD and motherboard vendors are acting quickly to patch issues found pre- and post-launch and this should be looked upon in a positive light, rather than negative.

Therefore, we plan to revisit Ryzen in the next couple of months, with a specific focus on DDR4-2933 and DDR4-3200 support. We will also have Ryzen 5 insights for you then as well. Stay tuned!

Test platform

Hardware:

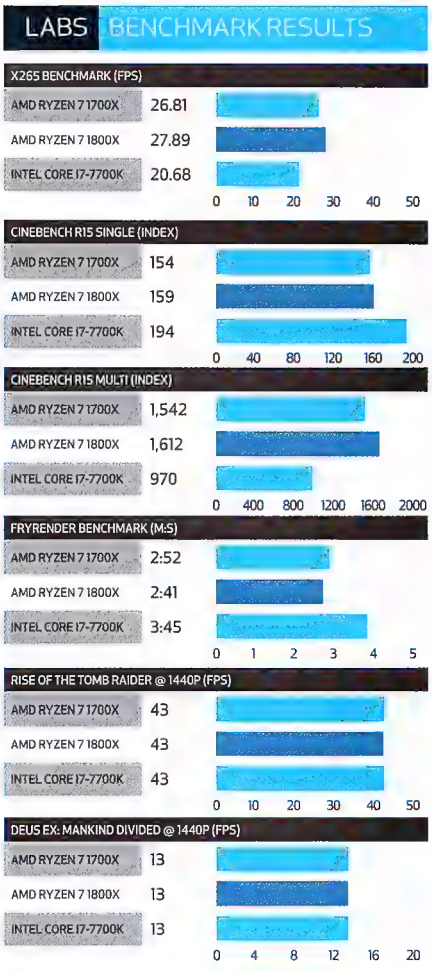
- AMD Ryzen 7 1800X w/ Noctua NH-U12S & EK-XLC Predator 240
- Intel Core i7 7700K w/ Noctua NH-U12P
- Intel Core i7 6900K/6950X w/ Bitspower water cooling
- ASUS RoG Strix Z270F Gaming
- ASUS RoG Rampage V Edition 10
- ASUS RoG Crosshair VI Hero
- Crucial Ballistix Elite 2x4GB @ DDR4-2400C15
- Crucial Ballistix Elite 4x4GB @ DDR4-2400C14
- Corsair Vengeance LPX 2x8GB @ DDR4-2666C14
- Nvidia GeForce GTX 1080 Ti Founders Edition
- Nvidia GeForce GTX 1080 Founders Edition
- Crucial MX300 525GB
- Corsair AX1200i
- Corsair AX860
- Corsair RM850x

AMD AM4 MEMORY CONFIGURATIONS

UDIMM MEMORY SLOT				MAXIMUM DRAM FREQUENCY
A1	A2	B1	B2	
-	SR	-	-	DDR4-2666
-	DR	-	-	DDR4-2666
-	SR	-	SR	DDR4-2666
-	DR	-	DR	DDR4-2400 TO DDR4-2666
SR	SR	SR	SR	DDR4-2133 TO DDR4-2400
DR	DR	DR	DR	DDR4-1866 TO DDR4-2133

SR = SINGLE RANK DIMM; 1RX4 OR 1RX8 STATED ON DIMM LABEL
DR = DUAL RANK DIMM; 2RX4 OR 2RX8 STATED ON DIMM LABEL

$540 | WWW.AMD.COM


LABS BENCHMARK RESULTS
X265 BENCHMARK (FPS)
AMD RYZEN 7 1700X 26.81
AMD RYZEN 7 1800X 27.89
INTEL CORE I7-7700K 20.68
0 10 20 30 40 50
CINEBENCH R15 SINGLE (INDEX)
AMD RYZEN 7 1700X 154
AMD RYZEN 7 1800X 159
INTEL CORE I7-7700K 194
0 40 80 120 160 200
CINEBENCH R15 MULTI (INDEX)
AMD RYZEN 7 1700X 1,542
AMD RYZEN 7 1800X 1,612
INTEL CORE I7-7700K 970
0 400 800 1200 1600 2000
FRYRENDER BENCHMARK (M:S)
AMD RYZEN 7 1700X 2:52
AMD RYZEN 7 1800X 2:41
INTEL CORE I7-7700K 3:45
0 1 2 3 4 5
RISE OF THE TOMB RAIDER @ 1440P (FPS)
AMD RYZEN 7 1700X 43
AMD RYZEN 7 1800X 43
INTEL CORE I7-7700K 43
0 10 20 30 40 50
DEUS EX: MANKIND DIVIDED @ 1440P (FPS)
AMD RYZEN 7 1700X 13
AMD RYZEN 7 1800X 13
INTEL CORE I7-7700K 13
0 4 8 12 16 20

AMD Ryzen 7 1700X

The Goldilocks of AMD's new Ryzen CPU range?

Let's assume you buy into the proposition offered by AMD's hot new CPU. You need to decide between the three eight-core models available from day one. While AMD has plans for quad- and six-core variants, they won't appear for several months. In the meantime, it's the launch trio of Ryzen 7 1700, 1700X, and 1800X that demands your attention.

For a $160 premium, the 1800X (reviewed in last month's *APC*) buys you 200MHz. No extra features, or cache memory, just a mere 5% uptick in operating frequency, in return for 25% more money. Ouch!

At the other end of the scale is the entry-level Ryzen 7 1700. For $450, it looks like a steal for a cutting-edge CPU, with eight cores, and 16 threads. But with a base clock of just 3GHz, and no support for AMD's new XFR automated overclocking feature, those savings come at a price.

So could the 1700X be "just right"? The clocks come in at 3.4GHz nominal and 3.8GHz Turbo. You get the same 16MB of shared L3 cache as the 1800X, and an unlocked multiplier for easy overclocking, plus the XFR feature. Time to find out what she'll do.

Most impressive is the chip's performance in highly parallel workloads, such as content creation and media encoding. Somehow, AMD's engineers have come up with a simultaneous multi-threading technology that's even more efficient than Intel's hyper-threading. The result is that this eight-core chip monsters tasks like video encoding and image rendering.

For those kinds of jobs, this chip is roughly on a par with Intel's $1,600 Core i7-6900K beast. Meanwhile, it utterly obliterates the best of Intel's CPUs for the mainstream LGA1151 socket, the $500 Core i7-7700K. Following that initial victory, the picture becomes more nuanced.

In anything single-threaded, this chip isn't such a killer. Depending on what Intel CPU you care to compare it with, you're looking at a performance deficit of around 10–20%. Roughly 10% of that is down to AMD's Zen architecture not being quite as powerful on a per-core and per-clock basis as Intel's latest CPU designs. The other 10% is thanks to clock speeds that are a little off Intel's pace.

Speaking of clock speeds, one disappointment with all Ryzen CPUs we've seen is moderate overclocking headroom. With an official Turbo speed of 3.8GHz, you might think 4GHz or more is on the cards, courtesy of that unlocked multiplier. Sadly not. Our sample chip could only keep together at 3.9GHz, making for an overclock of just 100MHz.

AMD's snazzy new XFR automated overclocking feature couldn't do any better, either. That said, in testing at stock settings, our 1700X ran at 3.5GHz during heavily threaded workloads. So 3.9GHz represents more like a 400MHz overclock.

Ryzen's most obvious weakness involves gaming. The fact that no existing PC games are compiled and optimised for what is a brand new CPU architecture is at least partly to blame. But there's no denying the 1700X sometimes struggles. Most of the time, that's moot. Whether you're getting 120fps or 150 is academic. But in those few titles that make heavy demands of your CPU, it could be the difference between smoothness and stutter. Of course, if you don't game, that hardly matters. For everything else, this is one hell of a CPU.

Jeremy Laird

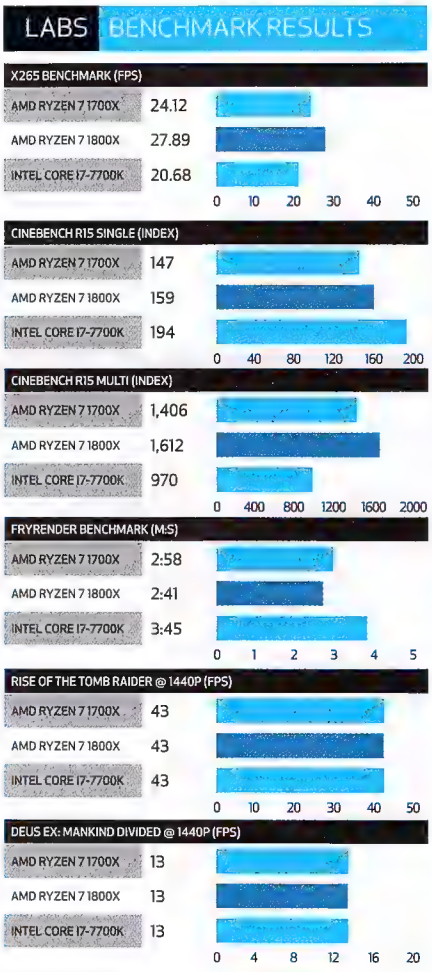
Verdict

Features	★★★★½
Performance	★★★★½
Value	★★★★★

Stunning multi-threaded performance; super-aggressive pricing; fully unlocked.

★★★★½

$450 | WWW.AMD.COM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AMD RYZEN 7 1700X 147
AMD RYZEN 7 1800X 159
INTEL CORE I7-7700K 194
0 40 80 120 160 200
CINEBENCH R15 MULTI (INDEX)
AMD RYZEN 7 1700X 1,406
AMD RYZEN 7 1800X 1,612
INTEL CORE I7-7700K 970
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INTEL CORE I7-7700K 43
0 10 20 30 40 50
DEUS EX: MANKIND DIVIDED @ 1440P (FPS)
AMD RYZEN 7 1700X 13
AMD RYZEN 7 1800X 13
INTEL CORE I7-7700K 13
0 4 8 12 16 20

AMD Ryzen 7 1700

Is this the new ruler of the value performance realm?

Breaking the norms of price to processing power is something AMD has progressively done with its Ryzen series of CPUs. Its 1800X and 1700X (page 45) have dominated our testing suites recently, butchering the competition. But both of those feel like mere footnotes in contrast to the sheer power AMD has managed to leverage into the core complexes buried at the heart of its Ryzen architecture.

We've repeatedly said that the 1800X and 1700X fall a little flat when it comes to overclocking, with the 1800X managing a meager 300MHz overclock, at most, on all of its cores, and the 1700X just a touch higher than that. Not too impressive for a chip with a 95W TDP. That said, for the price, and in contrast to their blue counterparts, both chips are simply staggering.

The 1700, then, makes the 1800X look like a kitten in comparison. Differences are few and far between: You lose out on the extended frequency (XFR) SenseMi software, which boosts a couple of cores higher, depending on your cooling solution, and the core clocks are far slower than either the 1700X or 1800X, coming in at a still respectable 3GHz, with a 3.7GHz turbo (only on four cores), but the 1700 has only a 65W TDP, as opposed to the 95W pumped into its power-hungry compadres.

By default, the performance figures are pretty solid – 24.12 frames per second in our X265 benchmark and 1,406 in Cinebench put this core in 6900K territory, a processor that comes in at a whopping $1,150 more. The thing is, this core doesn't stop there. All of Ryzen's lineup is overclockable on any X370 or B350 motherboard – and, holy cow, does this chip overclock! We managed to bump all eight cores up to 3.9GHz, with very little trouble. Temperatures peaked at around 65°C under load, utilising the NZXT Kraken X62, but what was more amazing was the fact that it even outperformed the the 1800X, while simultaneously drawing less power and running cooler (even allowing for AMD's erroneous 20° temperature boost).

Bumping the core clock up to 3.9GHz (bearing in mind that there have been reports of many hitting 4.1GHz under water), we saw an improvement of 18% in Cinebench R15's multi-threaded test, 7% in single-core performance, 20% in our X265 benchmark, and a 10% improvement in Fryrender, too. Which, let's face it, is truly incredible for a core that costs $450 – 50 bucks less than a Core i7-7700K.

So is it all a bed of roses? Not quite. Our sample was plagued by memory issues. Testing across multiple motherboards and memory kits, we struggled to get any to operate beyond 2,133MT/s. After speaking to AMD and running multiple tests, we came to the conclusion that our particular sample was damaged, so we wouldn't expect to encounter the same problems with other specimens.

Generally speaking, Ryzen's memory support isn't perfect just yet, and, yes, there are scheduling issues, but these are all to be expected with a brand new architecture design. Look back several years to Nehalem, and the birth of Intel's core architecture, and you can see the same issues occurring there, too.

Ultimately, however, teething issues aside, this chip is nigh on godly, and if you can't quite stretch to the 1700X, it's still a great runner-up. ■ Zak Storey

Verdict

Features ★★★★½
Performance ★★★★½
Value ★★★★½

Price to power is great;, plus some overclocking potential; solid for gaming but with teething issues.

★★★★½

$329 | WWW.ASROCK.COM

ASRock X370 Taichi

An exercise in finding one's zen.

The ASRock X370 Taichi has potential to steal attention based on the integrated connectivity possibilities. Like the MSI X370 XPower Gaming Titanium (see page 49), the ASRock X370 Taichi hosts dual M.2 slots for some speedy NVMe storage options. It's worth noting that these slots do share resources with PCIe expansion slots, with slot designated PCIE4 and PCIE5 disabling when M2_1 and M2_2 respectively are in use.

Continuing the storage I/O connectivity flamboyance is support for 10 — yes, 10! — SATA3 6Gbps connections. This is facilitated by eight ports connecting via X370 and the remaining two ports serviced via an ASMedia ASM1061 hub controller. Unfortunately, the documentation doesn't clearly state whether any of these connections are sharing resources with other I/Os. We wouldn't be surprised if utilisation of the dual M.2 slots would disable numerous SATA3 ports. This is when documentation needs to be accurate and clear to ensure consumers get what they're looking for and need.

The X370 Taichi also features an Intel Wireless-AC 3168NGW wireless NIC connecting to the board via an E-key M.2 port nestled near the rear I/O, with the 2T2R antenna connection on the rear I/O.

Sadly, much of this is a moot point given the board couldn't pass POST on anything other than stock defaults of DDR4-2133 C15. Therefore, that is what we had to test.

A shame really, because we hoped for a winner due to the intriguing spec.

Verdict

We wanted to like it, but our experience with the unit just couldn't let us.

★★½☆☆

$369 | WWW.ASUS.COM/AU

ASUS RoG Crosshair VI Hero

Quickly evolving from shotgun rails to sniper scope.

The ASUS RoG Crosshair VI Hero presented evolving functionality throughout testing. At one stage, a new BIOS with platform tweaks and updates was available every 2–3 days.

This scenario made for a very liquid testing environment. This situation isn't ideal for assessing a new product, much less something as complex as a new CPU and motherboard combination developed from a clean sheet. Yet, the silver lining is that we got to know the motherboards very well.

With DDR4-2666 the initial goal, the Crosshair VI Hero achieved this RAM performance level with minimal effort — a marked difference to some roundup contenders.

With the RAM parameters manually set, along with a tweak to the SOC voltage, the C6H delivered a strong base to benchmark the Ryzen CPU and assess the AM4 platform. In fact, the rapid rate of BIOS development and broader memory compatibility made the Hero our go-to 'board for testing the Ryzen CPU and AM4 platform.

Feature wise, the Hero currently packs everything into the board a user could want, most notably the plethora of USB ports on the rear I/O. One potential shortcoming is the inclusion of only one M.2 port.

There's so much more to share, yet space to do so is limited. With this in mind, let's cut to the chase.

The Crosshair VI Hero, at the time of print, is the best AM4 motherboard on the market, with only the Gigabyte AB350-Gaming 3 and Aorus X370-Gaming 5 knocking at its door.

Our advice? This is the one to get.

Verdict

This is the pick of the litter. There are other options, but this is the one you want.

★★★★½

$239 | WWW.ASUS.COM/AU

ASUS Prime X370-Pro

Primed for an average showing.

Slinking out of the shadows of its stablemate, the ASUS Prime X370-Pro is an allrounder type solution focused towards general desktop users. This target market may dip into creative workflows and gaming, but these are not the core focus of the board. These specific usage scenarios are simply something else it can do – there is no core focus.

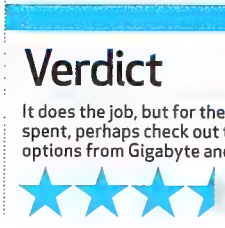
To be frank, this market position is largely due to the gaming sector dominating PC component sales and many other PC usage cases shifting to specialised or portable devices over the past decade. Nonetheless, this is how the Prime series from ASUS is pitched into the market. And for the most part, the Prime series does what it says on the box, and typically without much fanfare. Or hassle for that matter. It just does.

The X370-Pro was mostly unremarkable – namely, it neither disappointed nor inspired. That said, the unit still managed to obtain two podiums in the benchmark assessment with good results, in the X265 video encoding tests and second highest for total frames rendered in *Far Cry: Primal*. On that note, we guess it does demonstrate the quintessential status of an allrounder, with good ability in both work and play.

The X370-Pro has one point of differentiation to maintain a potential buyer's focus from the cheaper B350 offerings in this roundup. That is, the X370 chipset. But if build planning is done appropriately, the B350 options could deliver a comparable experience for less cost.

Verdict

It does the job, but for the money spent, perhaps check out the B350 options from Gigabyte and MSI.



$179 | WWW.GIGABYTE.COM.AU

Gigabyte AB350-Gaming 3

Do away with the howling winds and you've got a winner.

There's plenty of praise to be given for the performance of this relatively cheap unit. But let's first address something we came to dislike during the testing process: fan noise.

Whoever oversaw the mapping of the default fan profiles needs to go back to the drawing board. Or at least greatly improve the operational fan curve. Because what we found was the fan mounted to the CPU cooler, powered and managed via the CPU fan header on the motherboard, would consistently ramp the fan RPM up and down with such tenacity and frequency that it frankly became annoying. Even at idle. This could be worked around through custom fan profiles, but for many, the expectation is that the Gigabyte engineers have worked this stuff out already so the user doesn't have to.

Fan profiling gripes aside, coming through like the silicon embodiment of Steven Bradbury, the AB350-Gaming 3 snuck away with four podiums in testing, complete with two victories; one in PCMark 8, the other in 3DMark.

With performance that can rival the expensive boards in the roundup, the AB350-Gaming 3 beats direct competition on features. That is, the MSI B350 Tomahawk is outshone by the extra two SATA3 6Gbps ports on the AB350-Gaming 3, as well as the Realtek ALC1220, overshadowing the Tomahawk's Realtek ALC892.

A few extra volts were required to stabilise RAM, but once sorted, this board delivered overall and quite unexpectedly.

Verdict

Tweaks to minor aspects could make this a leader. The good news: that's possible via a BIOS update.

apc RECOMMENDS

$309 | WWW.GIGABYTE.COM.AU

Gigabyte Aorus X370-Gaming 5

A clear demonstration of equality returning.

The Aorus X370-Gaming 5 is smack in the middle of motherboards when it comes to cost. Yet, the performance strikes towards the top, even besting two tests. Some might say that is to be expected, but we hadn't expected the competitive price point.

Looking across the aisle to the blue side of the Aorus fence and the Z270X-Gaming 5 delivers comparable features at a comparable price. It's been a long time since we could make this kind of statement between an Intel- and AMD-derived platform from a single vendor. And you know what? We like it. We like it even more that the two sides of the CPU divide offer attractive solutions. The choice is fantastic to have once again and it creates significant opportunity for good value to be found by consumers.

While the X370-Gaming 5 may lack the additional M.2 and U.2 slot of its blue-hearted brethren, it is packed with eight SATA3 6Gbps ports, a single M.2 slot and a plethora of USB connections.

Pitched as a gaming 'board, the X370-Gaming 5 features the archetypal RGB flourishes, integrated throughout the 'board and serviced via one RGB header and one RGBW header. This appears peculiar at first but the logic fits. The RGB header services the potential installation of one of the new RGB LED lit AMD Wraith stock coolers, while the RGBW header continues Gigabyte's RGBW push started with the Intel 200-series product launches.

We really like the Aorus, but if you can stretch the budget to the Crosshair VI Hero (page 47), consider it.

Verdict

A top board, but squeezed by the B350 on the lower sector and the Crosshair VI Hero on the upper.

★★★★☆

$469 | AU.MSI.COM

MSI X370 XPower Gaming Titanium

Silver in colour, gold in price.

It's difficult not to be direct and quite blunt about the situation at hand when assessing the MSI X370 XPower Gaming Titanium versus the competition. Suffice to say, we weren't impressed. For a $469 motherboard – $100 more than the labs winner – and a product meant to be a jewel in MSI's crown, the X370 XPower simply fails to deliver for enthusiast users.

We tried numerous BIOS revisions to coerce some cooperation out of the unit. We didn't feel we were asking for much, just that the motherboard would deliver DDR4-2666 like all the competition, bar one. But like the X370-Taichi, the MSI X370 XPower Gaming Titanium simply didn't want to run at speeds beyond the default DDR4-2133. We persevered for the DDR4-2666 goal, buoyed by examples of the unit running DDR4-3200 in other's test scenarios, but ours didn't want to play.

After a few BIOS revisions and communication with MSI and AMD, we ultimately had to make the call to run the tests at DDR4-2133 so the board would at least be included in the roundup.

As mentioned in the Ryzen feature preceding this roundup, we intend to continue to explore the Ryzen-AM4 platform. The hope being that further BIOS development and *APC* labs testing will see the XPower fly high like it clearly has done so for others.

However, until our Hail Mary is answered, we can reflect on the fact the board is well featured, aesthetically intriguing and BIOS development has the potential to awaken the beast.

Verdict

A costly AM4 motherboard that struggles to justify its asking price among tight competition.

★★★☆☆

$179 | AU.MSI.COM

MSI B350 Tomahawk

Does it hit the target?

MSI's B350 Tomahawk hails from a pedigree of military-influenced, gaming-orientated 'boards called Arsenal Gaming. With motherboards in the range featuring titles like Camo Squad, Bazooka and Grenade, the Tomahawk doesn't seem like an extravagant moniker with these comrades.

Testing the Tomahawk revealed a motherboard that, at times, certainly took after its namesake, cruising into the fray and blasting big targets. A selection of podium finishes during benchmarking edged the B350 ahead of the ASUS X370-Pro, yet still trailing the front runners that established a credible lead.

From a general use perspective, the B350 Tomahawk was a pleasure to test. Unlike the Gigabyte AB350-Gaming 3, there were no irritating default fan profiles running amuck, yet a similarity we noticed was the tendency to require a bump in memory voltage to maintain stability throughout all tests. We found both the B350 units required a bump in vDIMM to encourage complete stability at DDR4-2666C14. We'll certainly be keeping an eye on this.

It lacks an abundance of SATA3 connections (only 4x on board), has no secondary RGB LED header, nor any true USB3.1 support, as well as sporting the Realtek ALC892 audio codec and Realtek 8111H NIC instead of the more premium Realtek ALC1220 and Intel I211-AT NIC, all paired with lower performance. It's not hard to see why the AB350-Gaming 3 is a better option.

But if quiet computing matters to you, get the Tomahawk instead.

Verdict

A pleasant surprise that unexpectedly beats units with significantly more frills.

★★★★

Just the start of the Ryzen story

Each month, we work tirelessly to deliver a consistently high quality of product reviews, investigative insight and general computing related understanding. This month is certainly no different and reflects why we've invested a significant amount of time and resources into exploring AMD's new Ryzen CPUs and associated AM4 motherboards.

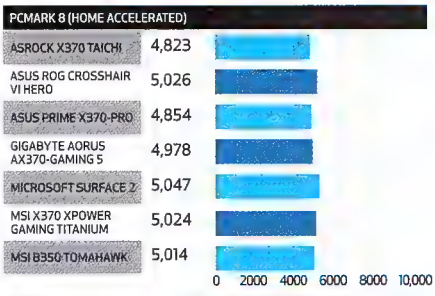
Even with this understanding and view of the bigger picture, with such a disruptive and overall important platform release from AMD — perhaps the most important in the past decade — it has been a troubled journey working towards conclusive, insightful, accurate and fair coverage of the associated technologies and products.

There is absolutely no denying that, when we started testing Ryzen and AM4 motherboards, the platform felt immature and required finessing to deliver the user experience expected by the general computing public. In fact, we would go so far as to say that, at times, testing the Ryzen-AM4 platform was downright frustrating and irritating. Yet we persevered, encouraged like a donkey with a carrot dangling in front of it, with the vision and hope that the new AMD setup would come good.

On this note, AMD's revolutionary new computing platform went through a rapidly evolutionary pre-release and immediate post-release development. It's difficult to transcribe to those that didn't go through the hands-on experience just how much progress was made in such a small passage of time between initial product sampling and the development of this content for you to enjoy.

It's on this note that we're buoyed and encouraged by this development progress and the commitment to this platform is clear from AMD and its motherboard partners. As such, we'll be following up this feature soon with an update on the Ryzen-AM4 experience, inclusive of some AM4 DDR4-3200 and Ryzen 5 testing — stay tuned!

LABS AM4 MOTHERBOARD BENCHMARK RESULTS


PCMARK 8 (HOME ACCELERATED)
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ASUS ROG CROSSHAIR VI HERO 5,026
ASUS PRIME X370-PRO 4,854
GIGABYTE AORUS AX370-GAMING 5 4,978
MICROSOFT SURFACE 2 5,047
MSI X370 XPOWER GAMING TITANIUM 5,024
MSI B350 TOMAHAWK 5,014
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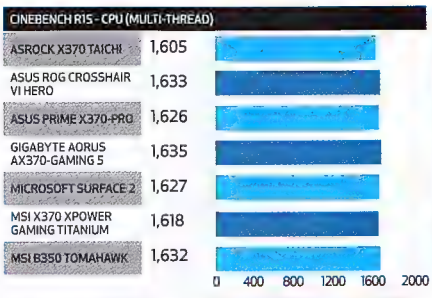
CINEBENCH R15 - CPU (MULTI-THREAD)
ASROCK X370 TAICHI 1,605
ASUS ROG CROSSHAIR VI HERO 1,633
ASUS PRIME X370-PRO 1,626
GIGABYTE AORUS AX370-GAMING 5 1,635
MICROSOFT SURFACE 2 1,627
MSI X370 XPOWER GAMING TITANIUM 1,618
MSI B350 TOMAHAWK 1,632
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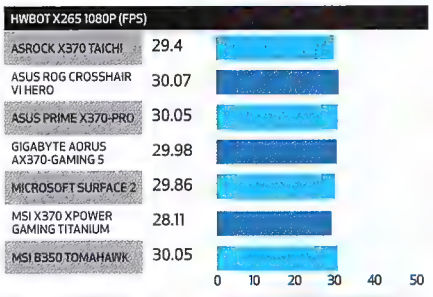
HWBOT X265 1080P (FPS)
ASROCK X370 TAICHI 29.4
ASUS ROG CROSSHAIR VI HERO 30.07
ASUS PRIME X370-PRO 30.05
GIGABYTE AORUS AX370-GAMING 5 29.98
MICROSOFT SURFACE 2 29.86
MSI X370 XPOWER GAMING TITANIUM 28.11
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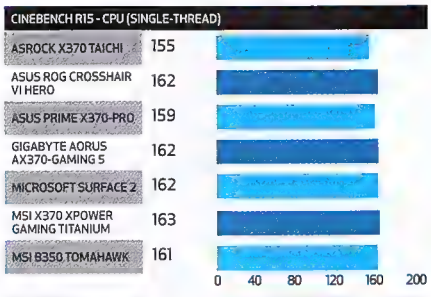
CINEBENCH R15 - CPU (SINGLE-THREAD)
ASROCK X370 TAICHI 155
ASUS ROG CROSSHAIR VI HERO 162
ASUS PRIME X370-PRO 159
GIGABYTE AORUS AX370-GAMING 5 162
MICROSOFT SURFACE 2 162
MSI X370 XPOWER GAMING TITANIUM 163
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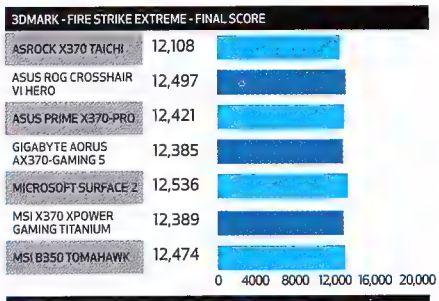
3DMARK - FIRE STRIKE EXTREME - FINAL SCORE
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ASUS ROG CROSSHAIR VI HERO 12,497
ASUS PRIME X370-PRO 12,421
GIGABYTE AORUS AX370-GAMING 5 12,385
MICROSOFT SURFACE 2 12,536
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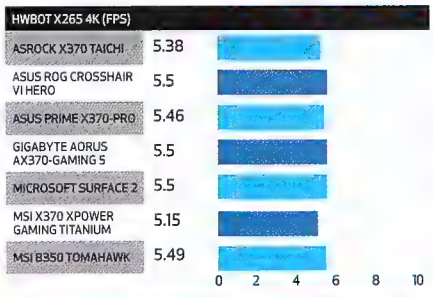
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ASUS ROG CROSSHAIR VI HERO 5.5
ASUS PRIME X370-PRO 5.46
GIGABYTE AORUS AX370-GAMING 5 5.5
MICROSOFT SURFACE 2 5.5
MSI X370 XPOWER GAMING TITANIUM 5.15
MSI B350 TOMAHAWK 5.49
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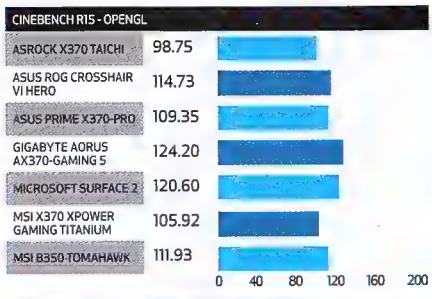
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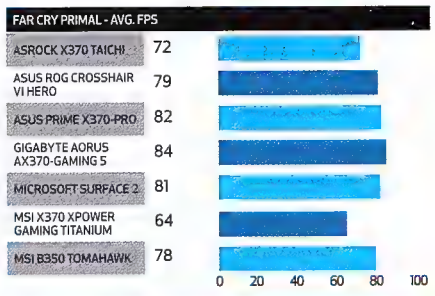
FAR CRY PRIMAL - AVG. FPS
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ASUS ROG CROSSHAIR VI HERO 79
ASUS PRIME X370-PRO 82
GIGABYTE AORUS AX370-GAMING 5 84
MICROSOFT SURFACE 2 81
MSI X370 XPOWER GAMING TITANIUM 64
MSI B350 TOMAHAWK 78
0 20 40 60 80 100

AM4 MOTHERBOARD SPECIFICATIONS

	ASROCK X370 TAICHI	ASUS ROG CROSS-HAIR VI HERO	ASUS PRIME X370-PRO	GIGABYTE AORUS AX370-GAMING 5	GIGABYTE AB350-GAMING 3	MSI B350 TOMA-HAWK	MSI X370 XPOWER GAMING TITANIUM
PRICE (AT TIME OF REVIEW)	$329	$369	$239	$309	$179	$179	$469
CHIPSET	AMD X370	AMD X370	AMD X370	AMD X370	AMD B350	AMD B350	AMD X370
AUDIO CODEC	REALTEK ALC S1220	REALTEK ALC S1220 W/ ESS ES9023P SABRE DAC (SUPRE-MEFX)	REALTEK ALC S1220A	REALTEK ALC1220 (SOUND BLASTER X-FI MB5)	REALTEK ALC1220	REALTEK ALC892	REALTEK ALC1220
NIC #1	INTEL I211-AT	INTEL I211-AT	INTEL I211-AT	INTEL I211-AT	INTEL I211-AT	REALTEK 8111H	INTEL I211-AT
NIC #2	INTEL WIRELESS-AC 3168NGW (2T2R)	-	-	KILLER E2500	-	-	-
RAM FREQUENCY (UP TO)	DDR4-3200	DDR4-3200	DDR4-3200	DDR4-3200	DDR4-3200	DDR4-3200	DDR4-3200
M.2 / U.2	2 X PCIE X4 M.2 (1 X SATA & PCIE, 1 X PCIE)	1 X PCIE X4 M.2 (MAX. TYPE-22110; PCIE AND SATA PROTOCOL)	1 X PCIE X4 M.2 (MAX. TYPE-22110; PCIE AND SATA PROTOCOL)	1 X PCIE X4 M.2 (1 X SATA & PCIE), 1 X PCIE X4 U.2 (SHARES RESOURCE WITH M.2)	1 X PCIE X4 M.2 (1 X SATA & PCIE)	1 X PCIE X4 M.2 (1 X SATA & PCIE)	2 X PCIE X4 M.2 (2 X SATA & PCIE), 1 X PCIE X4 U.2 (SHARED RESOURCE WITH M2_1)
SATA	10 X SATA 6GBPS (8 X VIA X370, 2 X VIA ASM1061)	8 X SATA 6GBPS	8 X SATA 6GBPS	8 X SATA 6GBPS (4 X STANDALONE, 4 X ACROSS 2 X SATA-EXPRESS SLOTS)	6 X SATA 6GBPS	4 X SATA 6GBPS	6X SATA 6GBPS
USB 3.1	X 2 (1 X TYPE-C, 1 X TYPE-A REAR I/O)	X 3 (1 X TYPE-C, 1 X TYPE-A REAR I/O; 1 X VIA HEADER)	X 3 (1 X TYPE-C, 1 X TYPE-A REAR I/O; 1 X VIA HEADER)	X 4 (1 X TYPE-C, 3 X TYPE-A REAR I/O)	X 2 (2 X TYPE-A REAR I/O)	-	X 3 (1 X TYPE-C, 1 X TYPE-A REAR I/O; 1 X VIA HEADER)
USB 3.0	X 10 (6X REAR I/O, 4 X VIA HEADERS)	X 10 (8 X REAR I/O, 2 X VIA HEADERS)	X 8 (6X REAR I/O, INC. 1 X TYPE-C; 2 X VIA HEADERS)	X 6 (2 X REAR I/O, 4 X VIA HEADERS)	X 6 (4 X REAR I/O, 2 X VIA HEADER)	X 8 (1 X TYPE-C, 3 X TYPE-A REAR I/O; 4 X VIA HEADERS)	X 8 (4 X REAR I/O, 4 X VIA HEADERS)
USB 2.0	X 4 (4 X VIA HEAD-ERS)	X 6 (4 X REAR I/O, 2 X VIA HEADERS)	X 4 (4 X VIA HEAD-ERS)	X 4 (4 X VIA HEAD-ERS)	X 5 (1 X REAR I/O, 4 X VIA HEADERS)	X 6 (2 X REAR I/O; 4 X VIA HEADERS)	X 7 (3 X REAR I/O, 4 X VIA HEADERS)
LIGHTING HEADERS	3 X RGB HEADERS	2 X RGB HEADERS	1 X RGB HEADERS	1 X RGB HEADER, 1 X RGBW HEADER	1 X RGB HEADER, 1 X RGBW HEADER	1 X RGB HEADER	1 X RGB HEADER
ONBOARD RGB	PCH HEATSINK	PCH, REAR I/O SHIELD	PCH, AUDIO PCB SPLIT	PEG SLOTS, CPU VRM, DIMM SLOTS, AUDIO SHIELD, "AC-CENT LED COVER"	AUDIO PCB GAP, "AC-CENT LED COVER"	N/A - RED REAR MOUNTED LEDS AROUND PERIPH-ERAL EDGE OF MOTHERBOARD	PCH HEATSINK, AUDIO PCB GAP
WARRANTY	3 YEARS	3 YEARS	3 YEARS	3 YEARS	3 YEARS	3 YEARS	3 YEARS

Build your own Ryzen PC

Budget? No, it's certainly not that — this is our AMD-powered, plug-and-play, rendering titan from Zak Storey.

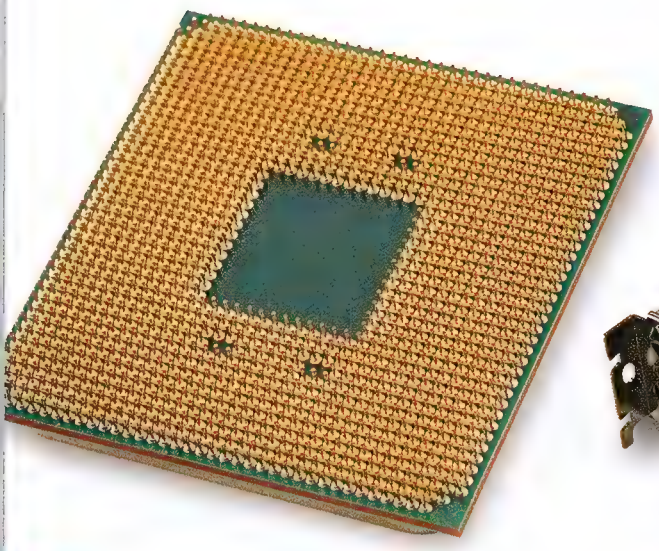
We've gone a little AMD mad this issue, as you can probably tell. The plucky underdog has really rattled the cages of the establishment. And, yes, although there are bugs – slowly being ironed out by developers and OS engineers alike – the value proposition put forward by AMD's new line-up of 7-series chips opens a whole plethora of new opportunities for those looking to supercharge their HEDT experience.

But first, let's get one thing straight: This is, by no means, a cheap build. Coming in at almost $7,400, this system holds nothing back when it comes to part selection, particularly on the storage front. Slapping 64GB of high-spec DDR4, 22TB of storage and an external NAS together bumps the price up by a staggering $4,308, accounting for an incredible 58% of the total expense. Selecting 32GB of 2,400MT/s DDR4, a 250GB PCIe SSD and two 2TB HDDs instead would drop the price significantly, bringing it down to a far more reasonable place for a high-end rendering station.

That said, as far as computational performance goes, and value per dollar, the core spec of this build is impressive, to say the least, smashing almost all of our system benchmarks, and hammering our zero-point system into the ground. With Ryzen's eight-core processors now cheaper than some of Intel's four-core Kaby Lake offerings, this could mark the beginning of the end for mainstream quad-core systems...

RYZEN PC INGREDIENTS

PART		STREET PRICE
CPU	AMD RYZEN 7 1800X	$689
CPU COOLER	EKWB EK-XLC PREDATOR 240 AIO	$269
MOTHERBOARD	GIGABYTE AORUS GA-X370-GAMING 5	$299
RAM	G.SKILL TRIDENTZ SERIES 64GB (4X 16GB) 3,200MT/S	$799
OS STORAGE DRIVE	SAMSUNG 960 PRO 2TB M.2 PCIE SSD	$1,699
DATA STORAGE DRIVES + NAS BOX	2x HGST ULTRASTAR HE10 10TB 7,200RPM + WD DISKLESS MY CLOUD EX2 ULTRA NAS	$1,810
GPU	EVGA GEFORCE GTX 1080 TI FOUNDER'S EDITION	$1,129
CASE	COOLER MASTER MASTERCASE MAKER 5T	$299
PSU	CORSAIR RMX 650W 80+ GOLD	$186
CASE COOLING	3 x EK VARDAR F4-120ER 120MM	$72
OPERATING SYSTEM	WINDOWS 10 OEM	$139
TOTAL		$7,390



CPU

AMD Ryzen 7 1800X – $689

It's weird having choice again, even in this climate of Ryzen 7 CPUs being available. For the best bang for your buck, you have three options: the 1700, the 1700X and the 1800X. In theory, the best chips for overclocking should be the 1700X and the 1800X — however, we've heard rumours suggesting that some 1700 chips are actually capable of out-clocking even the top-end 95W parts. That said, for stock clocks and reliability's sake, the 1800X is king of the hill, and although it may not be the best-value processor out there, it's still $800 less than its Intel equivalent.

GPU

EVGA GeForce GTX 1080 Ti – $1,129

Is this the true king of 4K gaming? Well, it's as close as you can get on a single card. The 1080 Ti, despite coming with a slightly silly spec (11GB of VRAM anyone?) is definitely the card to have if you're looking to hit that AAA 4K sweet spot. At least until the likes of Vega and Volta drop. On top of that, thanks to its CUDA core architecture, it syncs up exceptionally well with the likes of Adobe's Creative Suite — most notably Premiere Pro — making short work of all your HDR 4K rendering loads. The only drawback to this build? We wish we had another.

MOTHERBOARD

Gigabyte Aorus GA-X370-Gaming 5 – $299

Gigabyte's decision to migrate its Aorus branding across from its gaming laptops to its motherboards seems like a no-brainer. Combining the classic Aorus style and motif with a crisp mat white finish brings this board to the forefront of sleek system design. Couple that with a set of white Trident Z memory, and a few LEDs here and there, and it would be a dream in a black-and-white themed build. On top of that, there's a ton of connectivity, and solid thermals and power across the board. What's not to love?

CASE

Cooler Master MasterCase Maker 5t – $299

At first glance, the premium-looking MasterCase Maker 5t checks a lot of our boxes. Capable of supporting coolers up to 280mm in the front and roof, it's a modular heaven, with multiple configurations available through Cooler Master's in-house store. Unfortunately, it proved a bit more troublesome than we'd have liked once we got to building inside it, but it's hard to deny the build quality CM has leveraged on this. Although the sharp lines and bold red coloring might not be to everyone's tastes, it's a top-quality case, for people with very specific requirements.

Time to get building

A step-by-step guide to piecing together your very own Ryzen rendering PC.

1 STRIP THE CHASSIS

So you've got your parts, a suitable workspace set up, free from static-inducing materials, a dependable set of tools, including a couple of Phillips head screwdrivers, a ton of cable ties and you're ready to go. First thing you're going to want to do is strip down the chassis to the bare minimum. Not only does this give you a little extra room to manoeuver, but it also encourages you to get rid of any unnecessary clutter, reducing potential airflow problems, or creating turbulent hotspots.

Tempered glass and acrylic windowed panels are best placed in the cardboard box, slotted between the polystyrene to keep them protected. Most cases are relatively simple to take apart, but the 5t is another story. There's a plethora of screws attaching the top panel to the chassis itself, all of varying shapes and sizes. As pictured, there's also a radiator/fan mounting panel, held down by four retainable thumbscrews.

2 INSTALL THE POWER SUPPLY

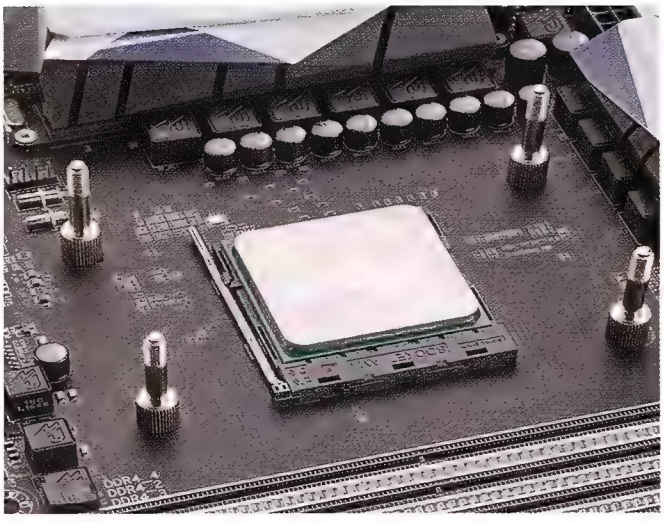
Ah, the beauty of a modular power supply! Corsair's RM series power supplies are a pretty affordable way of sprucing up any system. Although generally slightly longer than their non-modular cousins, being able to remove unnecessary cables from any build tends to make your life a lot easier.

With the MasterCase Maker 5t, the rear power supply bracket can be installed prior to sliding the power supply itself into the back of the case. Simply unscrew the four thumbscrews holding the bracket to the chassis, then use the included power supply screws to mount the bracket to the rear of the PSU. Make sure the fan is facing down, because the 5t lacks any top-sided ventilation, then simply slide the power supply into the back of the case, and secure it using the four thumbscrews once more.

3 REPLACE STOCK FANS

Although not an absolute necessity, replacing the stock fans in any chassis with something a touch more premium helps improve overall performance. As standard, the 5t comes with three black Cooler Master 140mm fans — we've replaced them with three EK Vardar 120mm fans, to reduce noise and improve airflow and static pressure.

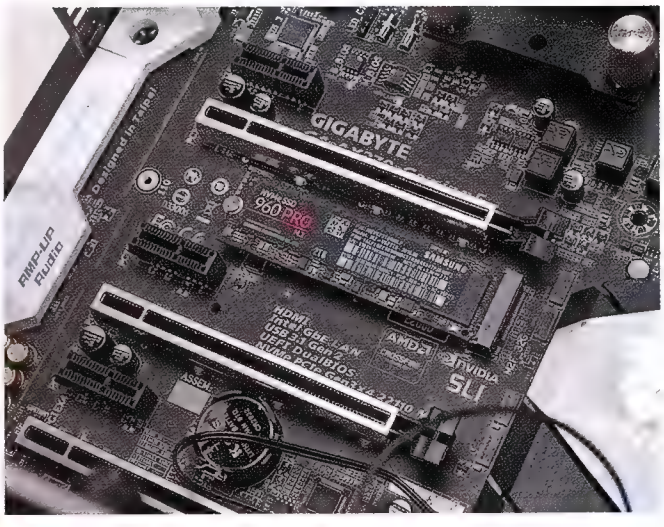
The original plan was to have the two Vardars at the front of the chassis, drawing air into the case, one exhausting out of the rear, then to use the AIO EK Predator, exhausting out of the roof, running in a slightly negative configuration. By the end of the build, our original plan had changed quite drastically, due to the limitations of the case itself — we talk about that more in our AIO section below, and in the conclusion.



4 INSTALL RYZEN AND AIO PREP

Installing LGA processors tends to be a bit of a nightmare — there's plenty of opportunity to bend those delicate motherboard pins, which can kill your trusty build. But with PGA processors, it's a far less dangerous business. Simply lift the retention arm up, match the golden triangle on the corner of the processor to the triangle on the socket, and carefully slot the processor into place. Wiggle it a bit, make sure it's snug and secure, with each pin in each hole, then lower the retention arm back into place.

Needless to say, this can be done when the motherboard is outside the case, and it's also the ideal time to install your AIO's backplate to the motherboard. For this particular cooler, you need to unscrew the default AMD bracket, align the EK backplate with rubber mounting in between, then thread the correct screws through it to lock it into place.



5 MOTHERBOARD AND AIO INSTALLATION

Next up, you'll want to install the motherboard into the case. Lay the chassis down on its side, install the rear I/O plate, making sure to orient it correctly, then screw the motherboard into the stand-offs at all available screw holes. With a case like the 5t, you need to add the stand-offs yourself, depending on the size of the motherboard you're using. Then things got interesting.

Due to a lack of clearances in the roof, we couldn't mount the EK Predator up above. After much shuffling, we opted to take the two 10TB HDDs out of the chassis, remove the HDD cage from the case, and install the Predator there, with the fans exhausting out of the front of the chassis. To mount the EK, simply apply a smidge of thermal paste to the centre of the processor, place the four springs on each mounting screw, gently line the block over the top of the screws until it slides down over the processor, then screw the AIO down with the included thumbscrews.

6 ADD THE PCIE M.2 SSD

Going from an SSD to a PCIe SSD is the equivalent of going from an old-school hard drive to an SSD for the first time. The extra speed, although not particularly noticeable on startup, is astronomical on desktop. Copying and transferring files around a PCIe SSD such as Samsung's 960 Pro is almost instant for anything less than 5GB.

Installation couldn't be easier, either. Locate the M.2 port on your board, find the screw opposite the port, and undo the tiny screw on the top of the mounting point. Next, make sure the stand-off is in the correct position for the size of M.2 SSD you have. If it's in the wrong place, use a pair of needle-nose pliers to undo it, and screw it into the correct position. Then line your SSD up with the notch on both the stick and the connection, and slot it into place, before securing it with the M.2 screw.

7 GPU AND MEMORY

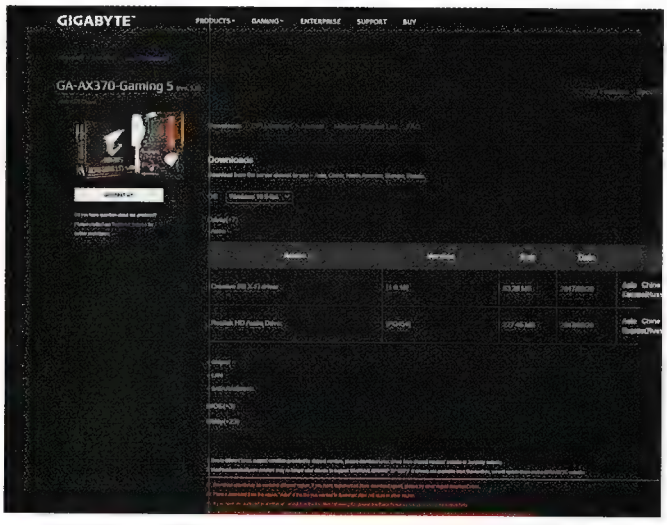
Almost at the end now. To install your graphics card, remove the two PCIe covers in the back of the chassis, where your card is going to slot in. These probably have two thumbscrews holding them in place. Then, lining the graphics card up with the slot, and with the rear I/O pointing to the back of the case, gently slot it into place until you hear a click. Then use those same thumbscrews that you removed earlier to secure the graphics card in place.

It's a very similar affair for memory. Make sure you match the off-centre notch on the stick with the board, lift the two clips either side of the memory slot, and gently slide the stick of RAM into place until you hear the two clips lock into place. Use the correct colour-coded slots if using only two sticks.

8 MORE LIGHTING

Once you've finished cabling up your system, and have routed everything out of the way (following the manual for front I/O headers), you'll want to deal with lighting — or maybe not, depending on your point of view. For us, it's part of what makes a system pop in a windowed chassis.

There's plenty of LED lighting in the MasterCase Maker 5t already, with a long strip located on the PSU cover, and our Aorus is littered with the stuff. We would have loved to have thrown a couple of extra white LED strips in the roof, and along the back or front, to really bring attention to that white motherboard, perhaps even disabling that red bar at the bottom, so as not to swamp out the white colour theme in a murky shade of rouge.



9 MIGRATE A WINDOWS INSTALL

So you've got fresh hard drives, everything's ready to go, the system's powering on, everything's spinning, and you're not getting any memory issues. What next? You'll want to install your OS. For us, that's Windows 10's Technical Preview. Ahead of time, utilising a laptop or your old system, you need to take an 8GB memory stick of some description, back up the documents on it elsewhere, and download the Windows Media Creation Tool from **bit.ly/Win10MediaTool**. Run the program, tell it you want to 'Create installation media for another PC', choose which version you want to make a USB installer for, hit Next, then point it at your USB stick.

The tool downloads the OS and creates a bootable USB stick, ready for your install. If you're migrating a build, now is a good time to find your activation key, either in an email, if you bought your install direct from Microsoft, or on your last Windows CD.

10 INSTALL THE OS AND DRIVERS

Plug the USB stick into your new machine. Power on your PC, and hammer Delete to get into the BIOS. Head to the Boot menu and make sure 'UEFI [insert name of USB stick]' is your first boot option. Then hit F10, save and exit, and wait for the Windows installer to boot up. Go through the Windows setup option. Don't worry when it asks you for your activation key — you can skip this until later if you don't have it immediately available. Choose which drive you wish to install the OS on (ideally your M.2 PCIe SSD), let it install, and then once it restarts, pull the USB stick out. Windows then gives you the usual privacy invading options, and asks you to sign in or create a Microsoft account, which you can skip. With the Aorus, install the appropriate network and chipset drivers. Head to Gigabyte's website, search for your mobo, and download the latest versions under Support. Then Google 'AMD Ryzen drivers', click the top link and download the latest AM4 chipset drivers.

1 A 650W power supply may seem a little lackluster for this build, but you can't really justify using more than a 700W power supply nowadays outside of multi-GPU setups and HEDT rigs.

2 This 5.25-inch front bay really did get on our nerves. Unfortunately, it's pop riveted into the chassis, and isn't removable — another disadvantage of the MasterCase Maker 5t.

3 The carrying handle at the top may look a little garish, but it does make it slightly easier to lug about than its competitors.

4 The biggest disappointment on this build was being unable to get the memory to clock any higher than 2,133. Hopefully, Gigabyte will release more BIOS updates soon to improve memory compatibility.

Rising to the challenge

Frustrating is the word with this one. AIO woes cut our enjoyment short midway through the build. Having to install our AIO in the front, because it was half an inch longer than the top mounting tray, was pure frustration, especially as the mobo and fans were already installed. On top of that, the fact that the front is now an exhaust goes against most common airflow conventions. It is possible to rotate the fans, but you need a particular set of hex keys that we didn't have to hand. To compensate for this lack of positive pressure, we installed all three remaining fans (two in the roof and one in the rear) to draw into the chassis instead. Combined with the blower fan, it should lead to a mostly balanced system, and we've yet to see any temperature anomalies.

To combat our hardware predicaments, we opted for an external NAS. The 2TB of applicable solid-state storage should be enough for any short-term content creation and file transfers, and the 20TB of HDD storage in the WD My Cloud Ex 2 Ultra should provide suitable backup for all long-term projects.

Having the PSU on rails, however, was a dream. Midway through the build, we decided to swap the stock cables for a set of black braided ones, and it was simply a case of pulling the PSU out, swapping the cables round, threading them through, and sliding it back into the chassis.

But what about performance? We decided to slap a 4GHz overclock on all eight cores, to give the processor a little extra grunt in rendering tasks and single-core IPC. What was disappointing was the memory overclocking. We struggled to get the memory to clock at 2,400MT/s, being forced to leave it at stock. Regardless of what timings we tinkered with, voltages we applied or memory profiles, the Gigabyte X370 didn't want to connect the dots.

As you'd expect, though, rendering performance was staggering, with nearly 1,700 points in Cinebench R15 multi-thread, and a solid 152 in single-thread. Backed up by 64GB of DDR4 and a 2TB PCIe SSD, it's not hard to imagine this thing flying when rendering everyday tasks.

And gaming? Well, that was a mixed bag of potatoes. AMD is still clearly having issues with a few titles, our *Total War: Attila* being the most telling, scoring just 36.2fps at 1080p. It's an aggressive title, no doubt, but when you consider that an Intel Pentium G4600 and GTX 1060 trumped this setup by a frame, it shows that optimisations need to be made. Whether that's on the OS or on AMD's side for chipset, it makes little difference to us.

Ultimately, Ryzen is a monster when it comes to professional workloads, board manufacturers still have to get up to par with memory compatibility, and gaming performance at lower resolutions could do with a tweak. But, bang for buck, it's damn near perfect, and will hopefully elicit a powerful response from Intel, too. ■

BENCHMARK RESULTS

	APC LABS TEST PC	THIS SYSTEM
CINEBENCH R15 MULTI-THREAD (INDEX)	923	1,697 (84%)
CINEBENCH R15 SINGLE-THREAD (INDEX)	179	152 (-15%)
CRYSTALDISK QD32 SEQUENTIAL READ (MB/S)	1,895	3,352 (77%)
CRYSTALDISK QD32 SEQUENTIAL WRITE (MB/S)	949	1,861 (96%)
TOTAL WAR: ATTILA (FPS)	43	36 (-16%)
RISE OF THE TOMB RAIDER (FPS)	67	89 (33%)
FAR CRY PRIMAL (FPS)	105	85 (-19%)

Our APC Labs test PC uses a Core i7-6700K CPU @ 4.6GHz, an AMD R9 Fury X, and 32GB of RAM. All games are tested at 1080p on max settings, with HD texture packages installed.

Eyes on the prize

Josh Collins tests a selection of curved PC monitors to find which ones have the right kind of flex and which can, well, just get bent.

Curved monitors are nothing new, but they're still little-understood by many PC pros and enthusiasts. Take a closer look at the specs, for example, and you'll begin to see the range of variation available on the market.

For many people, when they think about a curved monitor, they typically imagine an ultra-wide 21:9 aspect ratio display. This tends to hold true even for those who identify as PC enthusiasts and pride themselves on knowledge of products available in the market. If that rings true for you – news flash! Curved displays are available in 16:9 aspect ratio too, and we've got some to share with you.

Aspect ratio isn't the only variable, though: curved displays also come in a variety of curvatures. The bow of the panel and surrounding bezel is listed by a four-digit figure followed by an 'R'. The R is shorthand for 'radius' and the four-digit figure is the dimension of the radius of the curve in millimetres (mm). For example, 1800R refers to a display curvature that has a 1.80m radius.

THANKS TO MWAVE AND OFFICEWORKS

We reached out to a range of vendors for this roundup, but for a variety of reasons, many of the models we had hoped to include in this roundup were either entirely unavailable for review, unable to arrive in time to meet our deadlines or out with other reviewers. Such is life with media sample pools, however, we're fortunate to have some helpful retail contacts at Mwave (**www.mwave.com.au**) and OfficeWorks (**www.officeworks.com.au**) who stepped up to help supply some additional test samples.

Though we directly invited a huge range of vendors to submit review units for this round-up (including Acer, BenQ, Samsung, ViewSonic, Dell and others), scheduling and availability conflicts prevented many from participating. That said, this isn't the only time we'll be looking at curved displays this year – we'll be back with another round-up later in 2017 and, with a bit of luck, more of the usual suspects should be able to supply samples for that feature.

Test platform

Hardware:

- Intel Core i7-7700K w/ Noctua NH-U12P
- Gigabyte Aorus Z270X-Gaming 7
- Crucial Ballistix Elite 2x4GB @ DDR4-3000C15
- Nvidia GeForce GTX 1080 Ti Founders Edition
- Crucial MX300 525GB
- Corsair AX1200i
- X-rite i1Display Pro

Software:

- Microsoft Windows 10 (1607-14393.953)
- GeForce driver 378.92
- i1Display Profiler v1.6.7

CURVATURE: 1800R | $1,299 | AOCMONITOR-ANZ.COM

AOC Agon AG352UCG

A technically strong offering, but it could use a bit more finesse.

Unlike the MX34VQ, the AOC Agon AG352UCG immediately makes its presence known.

Visual presence occurs from the rear, courtesy of the aggressive angular design pushing the gamer-chic motif, complete with LED illumination. From the front, the AG352UCG pushes from piano black glossy bezels to diffused LED lighting through clear acrylic fascia elements.

The silver cast-metal stand is well formed in a delicate looking yet sturdy standing three-pronged solution. The forward facing two primary prongs create a sensual curve between the two forward contact points. The centre of the base is anchored to an upright neck that provides height adjustment, panel tilt and swivel. The top of this central structure also provides a useful handle for carrying the monitor. This is mighty handy when moving the unit around a room, though we don't envisage any regular LAN gamers wanting to take this unit on the road often – park it at home.

The OSD was a sticking point on this display. Unfortunately, a combination of on-screen menu jumps and unintuitive controls lead to OSD navigation being unenjoyable and even a little frustrating at times.

The AOC Agon AG352UCG has shortcomings. Yet, for the most part, these shortcomings either become insignificant during the thick of a gaming firefight or you simply adapt to accept that the unit is what it is. And when it's punching out 100Hz curved 3,440 x 1,440 gaming, it's nothing short of impressive.

Verdict

A technically capable display bound to impress, if you can overlook the minor shortcomings.

★★★★☆

CURVATURE: 2000R | $1,399 | WWW.ASUS.COM/AU

ASUS Designo MX34VQ

Gorgeous display, slightly frightening price tag, though.

This is the kind of display that you settle down in front of, pause for a moment and find yourself saying "Wow...!" – it's that impressive at first glance.

We see lots of different computer components, devices and gadgets pass through the *APC* Labs, yet every now and then, there's one that stops you for a moment. This moment can be one of great positive impression, or of disbelief that the product even got to market. In this case, we're happy to report it's the former.

Continuing the design ethos of the Designo MX series, the MX34VQ makes its presence known within a desktop setting, yet does so with a gentle softness – it's non-intrusive. And that's not easy for a 34-inch ultra-wide display to achieve, speaking volumes for the industrial design.

The MX34VQ features the same borderless bezel tech as in previous MX series displays, using the zero dot matrix to beautiful effect, creating an ultra-wide, curved panel that just is in front of you – no pressure.

It may seem like a lot of hyperbole being shared here, but it's done in a hope to express the impression gained during use. If you get a chance to use a MX34VQ, take that opportunity.

Given the tight radius of the curve, the MX34VQ benchmarked well with Delta-E values in-line with larger radius displays, reflecting the quality results for a smaller radius panel. Similarly, other aspects such as black levels, colour gamut, luminance and contrast ratio were all in-line with expectations.

Basically, it ticks the boxes it needs to in order to not just be a good looker.

Verdict

A gorgeous display that doesn't rely solely on the curved facia to dazzle and impress.

★★★★½

CURVATURE: 2000R | $1,299 | WWW.BENQ.COM.AU

BenQ XR3501

Almost has all the right specs. Almost.

Oh, XR3501, how we want to adore you. Dancing around in that attractive little 144Hz number, those long ultra-wide-screen runs of pixels... and then we look a little closer. It's at this stage, we wonder whether this display is the premium solution that we're lead to believe it is.

With a matte panel in a 35-inch ultra-wide-screen 21:9 aspect ratio form factor, cranking along at a rapid 144Hz refresh rate, the display is ultimately let down by its resolution and subsequent pixel density.

Stretching a resolution of 2,560 x 1,080 across the 35-inch display space results in a low pixel density of 79 pixels per inch (ppi). This reduced pixel density gives way to image reproduction that appears blurry and unsatisfyingly undefined. By contrast, the AOC unit (back over the page) is a similar 35-inch form factor and sporting a 2000R curvature rating. Yet, the AOC presents a crisp, detailed image reproduction for the most part enabled by the display's pixel density of 106 ppi.

The rapid refresh rate is a desirable attribute for many gamers that prefer the fast pace of first-person shooter titles or driving games. However, when considered as the sum of its parts, especially when placed into the same consideration as contemporaries like the ASUS MX34VQ and AOC Agon AG352UCG, based on the price point, the 144Hz refresh doesn't stand out sufficiently to justify the reduced resolution of 2,560 x 1,080 – you're left wanting for the extra pixels to go pushing the simply more impressive 3,440 x 1,440 resolution.

Verdict

Pixel density isn't high, so if you're used to a fine image, you'll find this display blur-inducing.

★★★½☆

CURVATURE: 4000R | $387 | WWW.PHILIPS.COM.AU

Philips 279X6QJSW

It is curved... isn't it?

The 279X6QJSW presented us with a unique and peculiar initial impression. We were left trying to confirm the main trait for inclusion in this roundup – curvature.

Sporting a wide radius curvature rating of 4000R, this attribute paired with a 16:9 aspect ratio makes for a display that doesn't proclaim its curvature as prominently as the ultra-wide displays. Nevertheless, that's not to say that a display can't conform to the 16:9 aspect ratio and still prominently present its curved nature. As this perspective would ignore the fact that the Samsung C24F390FH delivers such that – a noticeably curved 16:9 display. Furthermore, it achieves the outcome with a 24-inch form factor solution. This would traditionally further reduce the prominence of the curvature, yet this isn't the outcome.

Like the BenQ unit, the Philips also suffers from low pixel density. Stretching the 1,920 x 1,080 Full HD resolution over a 27-inch panel doesn't lead to a noticeably crisp resolution. In this form factor, typically the go-to resolution is 2,560 x 1,440-pixels, however, with 1,920 x 1,080-pixels resulting in 81ppi, the user is left wanting.

Sporting a glossy panel finish, the Philips is not ideal for use in areas with direct sunlight and other lighting flare influences.

Featuring restricted ergonomics and few significant redeeming features, we can't help but to suggest there are better options to consider. And with the specs the unit does have, you've got to wonder how much the curved panel really matters.

Verdict

Not much of a curve, and for the effort made, why not just look at a flat panel option instead?

★★½☆☆

CURVATURE: 1800R | $327 | WWW.SAMSUNG.COM/AU

Samsung C24F390FH

A curved 16:9 panel that actually looks curved.

Unlike the Philips option (left), this Samsung C24F390FH has a noticeably curved display in a 16:9 aspect ratio. This outcome is achieved using a panel with a 1800R curvature rating – a significantly tighter curve.

Though the curvature is noticeable by comparison with the Philips, the display still demonstrates that curved panels are most impactful in the 21:9 aspect ratio and subsequent ultra-wide form factor.

Also boding well for the Samsung C24F390FH while duking out for 16:9 curved display supremacy in this roundup is the inclusion of a VESA mount, albeit the less prominent 75mm x 75mm solution. While it may be reduced from the typical 100mm x 100mm VESA mounting solution, at least it's an option that could be handy for some users to have either immediately in the product use cycle or later as ownership use evolves.

Sporting just a single HDMI v1.4 connector and a D-Sub connection with 3.5mm audio out, too, the unit is light on connectivity options.

Another scope of interest that we perceive the Samsung unit getting right is the inclusion of a matte panel finish. Regardless of how positive a gloss display may appear in a controlled lighting environment, once taken out of this space, the gloss feature often becomes a hindrance to fully appreciating the display in practical usage.

This proved true in practicality when testing the Philips and Samsung S34E790C, with the matte finish on the Samsung C24F390FH well received.

Verdict

A suitably understated yet capable display, there's no significant standout quality, it just works.

★★★☆☆

CURVATURE: 3000R | $959 | WWW.SAMSUNG.COM/AU

Samsung S34E790C

A competent unit, but for this price?

The Samsung S34E790C has an allrounder purpose in its role within the curved monitor roundup, with an existence geared towards content creation and consumption, and general usage.

If looking to game or enjoy high refresh rate content on an ultra-wide 21:9 aspect ratio display, we recommend saving your funds for a little longer and considering the purchase of one of the units in this roundup from ASUS, AOC or BenQ.

As an earlier product to the curved monitor market, the Samsung S34E790C sports a gentle panel curvature, flaunting a 3000R rating – preferable when viewing from a further distance. However, in a desktop scenario with a user typically sitting within a metre of the display, the impact of the 1800R curvature of the ASUS MX34VQ is noticeably influential by comparison.

Unlike other displays in the roundup, the Samsung S34E790C provided some meaningful spec details regarding colour gamut coverage, highlighting its capability to represent 76% of the AdobeRGB spectrum – a fair effort. Colour depth is apparent when viewing the display, though we couldn't help but to be distracted by visual flares when viewing the glossy panel. Gloss finishes can have a positive impact on gamut reproduction – certainly so with clearly defining blacks – yet the visual disturbance of lens flares often proved overwhelming.

The S34E790C presents well, complete with a stand that mimics the curvature of the screen, emphasising its core feature – well played, Samsung.

Verdict

A competent entry to the market, but consider saving for the more premium MX34VQ experience.

★★★☆☆

CURVED MONITOR SPECIFICATIONS

	ASUS MX34VQ	AOC AGON AG352UCG	BENQ XR3501	PHILIPS 279X6QJSW	SAMSUNG C24F390FH	SAMSUNG S34E790C
PANEL SIZE:	34"	35"	35"	27"	24" (23.6")	34"
RADIUS OF CURVATURE:	1800R (1.80M)	2000R (2.00M)	2000R (2.00M)	4000R (4.00M)	1800R (1.80M)	3000R (3.00M)
PANEL TYPE:	VA	AMVA	AMVA	MVA	SVA	SVA
PANEL BACKLIGHT:	W-LED	W-LED	W-LED	W-LED	W-LED	W-LED
PANEL BIT DEPTH:	8-BIT	8-BIT	8-BIT	8-BIT	8-BIT	8-BIT
FRAME RATE CONTROL (FRC):	NO	NO	NO	NO	NO	NO
PANEL MANUFACTURER:	N/S	AU OPTRONICS	AU OPTRONICS	N/S	SAMSUNG	SAMSUNG
PANEL MODEL:	N/A	M350QVR01.0	M350DVR01.0	N/A	N/A	LTM340YP01
REFRESH RATE:	100HZ	100HZ	144HZ	60HZ	60HZ	60HZ
MINIMUM RESPONSE TIME:	4MS	4MS	4MS	4MS	4MS	4MS
PANEL FINISH:	MATTE	MATTE	MATTE	GLOSS	MATTE	GLOSS
MAX. LUMINANCE (CD/M2):	300	300	300	300	250	300
ASPECT RATIO:	21:9	21:9	21:9	16:9	16:9	21:9
RESOLUTION:	3,440 x 1,440	3,440 x 1,440	2,560 x 1,080	1,920 x 1,080	1,920 x 1,080	3,440 x 1,440
PIXEL DENSITY:	109 PPI	106 PPI	79 PPI	81 PPI	93 PPI	109 PPI
STATIC CONTRAST RATIO:	3,000:1	2,000:1	2,000:1	3,000:1	3,000:1	3,000:1
HORIZONTAL VIEWING ANGLE:	178 DEGREES	178 DEGREES	178 DEGREES	178 DEGREES	178 DEGREES	178 DEGREES
VERTICAL VIEWING ANGLE:	178 DEGREES	178 DEGREES	178 DEGREES	178 DEGREES	178 DEGREES	178 DEGREES
SRGB GAMUT COVERAGE:	100%	100%	100%	N/S	N/S	99%
SPEAKERS:	2 x 8 WATTS	2 x 2 WATTS	NONE	NONE	NONE	2 x 7 WATTS
CONNECTIVITY	DP x 1, HDMI x 3	DP x 1, HDMI x 1	DP x 1, HDMI x 2	DP x 1, HDMI x 1, D-SUB x 1	HDMI x 1, DVI x 1	DP x 1, HDMI x 2

CURVED MONITOR BENCHMARK RESULTS

	ASUS MX34VQ			AOC AGON AG352UCG			BENQ XR3501		
CURVATURE:	1800R			2000R			2000R		
LUMINANCE (CD/M2):	243			203			298		
CONTRAST RATIO:	1,944:1			1,138:1			1,930:1		
COLOUR ACCURACY (GAMUT COVERAGE):	GOOD			GOOD			GOOD		
CIE1976 AVERAGE DELTA-E:	1.39			0.89			0.99		
CIE1976 MAXIMUM DELTA-E:	5.33			6.18			4.91		
CIE2000 AVERAGE DELTA-E:	0.92			0.58			0.63		
CIE2000 MAXIMUM DELTA-E:	2.57			3.05			2.29		
BLACK LEVELS SUMMARY:	GOOD			EXCELLENT			GOOD		
FIRST FULLY DISTINGUISHABLE BLACK LEVELS BOX:	4			1			4		
HIGHEST LUMINANCE DELTA:	14%			13%			19%		
DISPLAY UNIFORMITY & LUMINANCE DELTA (WHITE: 255, 255, 255):	LD: 13% LUM: 208	LD: 14% LUM: 205	LD: 12% LUM: 211	LD: 13% LUM: 177	LD: 7% LUM: 189	LD: 9% LUM: 186	LD: 12% LUM: 264	LD: 2% LUM: 292	LD: 14% LUM: 258
	LD: 9% LUM: 217	LUM: 241	LD: 7% LUM: 224	LD: 7% LUM: 189	LUM: 205	LD: 5% LUM: 194	LD: 16% LUM: 251	LUM: 301	LD: 19% LUM: 242
	LD: 11% LUM: 214	LD: 6% LUM: 225	LD: 11% LUM: 213	LD: 4% LUM: 195	LD: 1% LUM: 208	LD: 1% LUM: 201	LD: 8% LUM: 276	LD: 3% LUM: 313	LD: 10% LUM: 269

VENDOR:	PHILIPS 279X6QJSW			SAMSUNG LC24F390			SAMSUNG S34E790C		
CURVATURE:	4000R			1800R			3000R		
LUMINANCE (CD/M2):	233			221			296		
CONTRAST RATIO:	2,109:1			2,95:1			2,203:1		
COLOUR ACCURACY (GAMUT COVERAGE):	FAIR			FAIR			GOOD		
CIE1976 AVERAGE DELTA-E:	0.97			0.83			1.03		
CIE1976 MAXIMUM DELTA-E:	8.45			8.74			4.59		
CIE2000 AVERAGE DELTA-E:	0.56			0.48			0.62		
CIE2000 MAXIMUM DELTA-E:	3.81			4.09			1.97		
BLACK LEVELS SUMMARY:	FAIR			GOOD			GOOD		
FIRST FULLY DISTINGUISHABLE BLACK LEVELS BOX:	5			4			3		
HIGHEST LUMINANCE DELTA:	8%			9%			14%		
DISPLAY UNIFORMITY & LUMINANCE DELTA (WHITE: 255, 255, 255):	LD: 8% LUM: 215	LD: 5% LUM: 220	LD: 6% LUM: 218	LD: 1% LUM: 216	LD: 5% LUM: 209	LD: 6% LUM: 206	LD: 13% LUM: 255	LD: 7% LUM: 272	LD: 5% LUM: 274
	LD: 7% LUM: 217	LUM: 234	LD: 3% LUM: 226	LD: 2% LUM: 215	LUM: 220	LD: 3% LUM: 213	LD: 11% LUM: 262	LUM: 295	LD: 3% LUM: 286
	LD: 8% LUM: 214	LD: 2% LUM: 227	LD: 4% LUM: 224	LD: 6% LUM: 205	LD: 9% LUM: 200	LD: 9% LUM: 199	LD: 14% LUM: 252	LD: 9% LUM: 267	LD: 7% LUM: 274

Next-gen SSDs on test

Forget those old 2.5-inchers — Josh Collins explores the shiny new M.2 and PCIe-card SSDs to find out what's hot and what's not.

The Next Generation Form Factor (NGFF) SSD standard has provided a development platform for newer, faster and smaller PC storage devices, featuring a new physical interface and support for multiple communication protocols. What's emerged as the dominant solution during this development is the 22mm-wide M.2 form factor, typically ranging in lengths from 30mm through to 110mm, depending on capacity. For example, a '2280' M.2 drive – the most common standard size for M.2 drives – uses a 22mm-wide connection interface with a PCB length of 80mm.

Test platform

Hardware:

- Intel Core i7 7700K w/ Noctua NH-U12P
- Gigabyte Aorus Z270X-Gaming 7
- Crucial Ballistix Elite 2x4GB @ DDR4-3000C15
- NVIDIA GTX 1080 Ti Founders Edition
- Crucial MX300 525GB SSD (for operating system)
- Corsair AX1200i

Software:

- Microsoft Windows 10 (1607-14393.953)
- CrystalDiskMark 5.2.0
- AS SSD Benchmark 1.9.55986.35387
- Anvil's Storage Utilities 1.1.0

Methodology:
All drives tested as empty, freshly formatted drives for maximum performance.

NGFF drives can actually handle multiple communication protocols, with SATA 6Gbps, USB 3.0 and PCI-Express (PCIe) all technically supported. Different module keying – configs of the gold connectors that are used to plug devices in – is used to differentiate between the various interface and protocol offerings. For this roundup, we saw two types of keying. The first was the M-key type, used by devices that feature PCIe x4 support, while the second was the M+B-key type, which incorporates both an M-key and B-key. The latter devices are able to communicate via protocols based on PCIe or SATA 6Gbps.

In this feature, we've primarily focused on M.2 drives based on the 2280 form factor, with 22mm-wide connection interfaces and PCBs reaching 80mm in length – unit thicknesses varies widely, often depending on drive capacity. The tested units are further split into two core communication protocols: SATA 6Gbps and NVMe (aka 'Non-Volatile Memory express' standard).

Another derivative of the NGFF category is the SFF-8639 interface that was renamed U.2, post launch. M.2 and U.2 present the same connectivity bandwidth and both can reach their maximum bandwidth performance through use of four PCI-Express lanes. The M.2, U.2 and PCIe slot (PCIe x4) interfaces are all inter-operable due to using the same communication protocol, allowing for potential NVMe RAID solutions that run across M.2, U.2 and PCIe add-in-card interfaces. We've included Intel 750 series and HyperX Predator PCIe slot NVMe SSDs in the roundup for comparison. The PCIe x4 logical device interface provides a 32Gbps link, while SATA 6Gbps (obviously) provides a 6Gbps communication link.

Thanks again to Mwave

A big thanks to tech retailer Mwave (**www.mwave.com.au**) for again providing many of the samples used in this storage comparison, without which we wouldn't have been able to test such a wide range of products.
We appreciate the support.

PCIE X4 M.2 AND PCI-CARD BASED SSDS

$149 | WWW.CORSAIR.COM

Corsair Force Series MP500 120GB

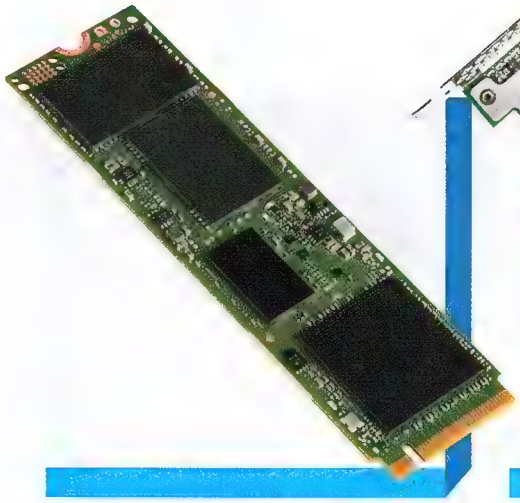
Is this *Return of the Jedi* or *Attack of the Clones?*

The MP500 was brought into the lab with some lofty expectations as it had garnered a reputation as a competitor to Samsung's 960 series. Note: The performance of an SSD varies depending on its capacity and the density of the integrated memory modules – typically the larger drives show higher performance. The samples provided direct from Corsair for review are typically the 240GB and 480GB variants. Upon checking the MP500 spec in detail, one can observe a distinct difference in claimed specification between the 120GB unit and its siblings, with the two larger units delivering mirrorable claimed performance. We advise keeping your distance from the 120GB variant we've tested. Performance was not at the desirable levels teased by the 240GB/480GB variants and write performance was shocking to say the least. Great for storing read-only resources that require quick access, otherwise spend your money elsewhere.

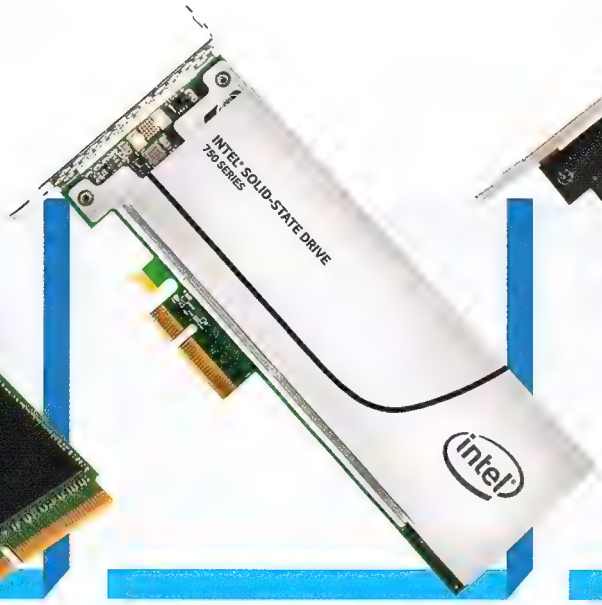
Verdict

The 120GB leaves us wanting more, but we're lead to believe the 240GB and 480GB variants would deliver.

★★



$279 | WWW.INTEL.COM



$1,189 | WWW.INTEL.COM

$265 | WWW.HYPERXGAMING.COM

Intel 600P 512GB

Intel's attempt at an NVMe drive for the masses.

Let's get one thing straight: the Intel 600P will not and cannot compete with the Samsung NVMe drives. Now that we've got that out of the way, let's consider a few things. The 600P opens the Intel NVMe product stack at a significantly cheaper price point than the 750 series. By comparison, a 1TB version of the 600P goes for just shy of $0.50 per GB, whereas a 1.2TB version of the 750 series goes for about $1 per GB. This stark contrast in cost highlights one advantage held by the 600P drives – cost versus density. While the 600P isn't going to win any performance crowns, the 600P range still fills a valuable market position. The drives create a bridge between high performance NVMe drives and performance orientated variants of SATA 6Gbps drives. With write speeds representative of high-end SATA3 drives, it's the triple-speed read performance that sees the 600P distance itself from SATA 6Gbps contemporaries.

Verdict

A bridge between high-end SATA3 and high-end NVMe performance, the 600P strikes a respectable middle ground.

★★★☆☆

Intel 750 Series 1.2TB (PCIe AIC)

The original king, but how does it reign now?

The original king of the NVMe game, the Intel 750 Series was a formidable offering upon launch. Bringing to market a fast and reliable storage solution based on NVMe technology, the Intel 750 series uses the Intel CH29AE41AB0 controller paired with Intel's 20nm MLC NAND flash memory to provide a total unformatted storage capacity of 1.2TB, backed by a 5-year warranty. When this product launched, it was a drool-worthy piece of kit. Now, with the continued development of NVMe technology, the Intel 750 Series is starting to show its age. Consider this: for almost half the price of this unit, a Samsung 960 Evo 1TB could be purchased, delivering faster performance. Furthermore, two 960 Evo 1TB drives in RAID can be obtained for similar money to a 750 Series 1.2TB PCIe Add-in-Card (AIC) and have the flexibility to provide increased performance (RAID0) or increased data security (RAID1) – this is the final nail in the coffin of the 750 series.

Verdict

Value is no justification for this drive, but Intel's renowned reliability and a data centre orientated controller are both significant positives.

★★½☆☆

Kingston HyperX Predator 240GB

Time to say goodbye?

The HyperX Predator comes in two offerings – a half-height, half-length (HHHL) PCIe slot add-in-card adaptor along with the M.2 drive, and one with just the M.2 drive. The HHHL adaptor provides potential versatility when considering system-wide PCIe resource allocation and connectivity to support the PCIe x4 link speed, through either a PCIe slot using the HHHL adaptor or via a M.2 socket. Coming to market in the first wave of PCIe x4-based NGFF SSDs, the Predator is a step above even the fastest-performing SATA 6Gbps SSDs, showing a general read of 1,400MB/s and write of 800MB/s – exceeding the vendor claimed 600MB/s write. However, in the scope of competitor NVMe SSDs, the Predator has aged. Once again, the 960 Evo makes the competition look laughable. Looking at the buying price, spending just $70 more nets you the Samsung 960 Evo 500GB – it's simply an argument that can't be fought.

Verdict

A drive that has passed its market viability for enthusiasts and performance-orientated users.

★★☆☆☆

$419 | WWW.SAMSUNG.COM/AU

$339 | WWW.SAMSUNG.COM/AU

$515 | WWW.SAMSUNG.COM/AU

Samsung 950 Pro 512GB

The king regent now left behind by progress.

The 950 Pro was the king when it entered the market to compete with Intel's 750 Series SSDs. It brings with it performance that defeats the Intel 750 on essentially every level covered in this roundup. Yet, the drive still pales in comparison to the Samsung 960 Pro and 960 Evo (right). There are two core considerations when assessing the inclusion of the 950 Pro in this roundup. These are: the prevalence of the drives among enthusiast end-users, and the continued availability within the channel marketplace. With these two aspects in mind, the labs benchmark results quickly prove that substantial gains have been made in the 960 series of products and even though the drives may still be present in the market, they no longer present good value for money – the 960 Evo is cheaper and faster, while the 960 Pro isn't that much more expensive. Unless you score a great second-hand deal, consider the newer 960 series drives instead.

Verdict

Still fast compared to some options, but if you're buying new, be sure to get a 960 series drive — the 950 has had its day.

★★½☆☆

Samsung 960 Evo 500GB

Great value for money, even at this price point.

The Samsung 960 Evo is the high performance NVMe SSD designed to capture a broader market audience than the 960 Pro. There are three key areas of focus in which the 960 Evo takes a step back from the 960 Pro: performance, endurance and warranty. The Pro and Evo use the same Samsung Polaris derived controller, however paired with different flash memory NAND – MLC for Pro and TLC for Evo. The warranty is represented by two key aspects, the drive endurance – typically measured in terabytes written (TBW) – and the manufacturer supported warranty period. The Evo typically has half the endurance, i.e. 400TBW for the 960 Pro 512GB and 200TBW for the 960 Evo 500GB, and the Pro series has a 5-year warranty versus the 3-year warranty of the Evo. For most users, the 960 Evo delivers plenty of NVMe performance and you'll no doubt be looking at an upgrade by the time the warranty is over.

Verdict

The pick of the bunch, the 960 Evo welds value and performance with seemingly effortless ease.

★★★★½

Samsung 960 Pro 512GB

All hail the reborn king!

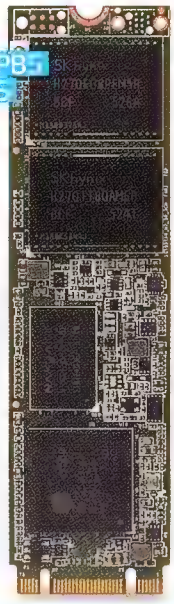
There was a chance this roundup wouldn't have the category king in it. We had a surprising amount of trouble securing a sample of the Samsung 960 Pro, with Samsung ANZ being out of available samples. Luckily, all was not lost with Capitol Computer (**www.capitolcomputer.com.au**) coming in to support this review. We knew what to expect from the Samsung 960 Pro 512GB and it never failed to deliver. The 960 Pro lead performance benchmark figures across the board. Whether assessing complete, large files or smaller files with large queue depths, the 960 Pro delivered time and again. Scoring a maximum 3,530MB/s read result in CrystalDiskMark 5, the score suggests Samsung doesn't have much development scope left before knocking on the limitations of the PCIe x4 bus, with maximum theoretical bandwidth of 3,938MB/s. If you want the best, then this is it, but you will pay more for it.

Verdict

If SSDs had a sound effect, then the 960 Pro would sound like a Lexus LFA screaming past at full throttle — VROOOOOM!

★★★★☆

SATA 6GPBS M.2 SSDS



$579 | WWW.INTEL.COM

$145 | WWW.WD.COM

$120 | WWW.WD.COM

Intel 540S 1TB

After a drive with more capacity?

Based on SATA3 and conforming to the M.2 form factor, the Intel 540S steps into the fore pushing quantity over quality when it comes to capacity (memory density) versus performance. From the perspective of NVMe drives, the statement holds true. From the perspective of the established SATA3 SSD performance norms, the read performance is right up there with the best of them, while comparatively taking a hit on the writes. But a write performance of 480MB/s for a SATA3 drive is still good and most end-users won't notice the difference between 480–500MB/s and 500–535MB/s. This leaves drive capacity, and in this respect, the drive delivers with a tasteful cost of ~$0.57 per gigabyte of unformatted storage. By comparison, the 960 Pro is $0.88/GB. If speed isn't your focus and drive capacity matters, all while requiring or having a strong preference for M.2 form factor, then in that usage scenario, the Intel 540S 1TB makes absolute sense.

Verdict

When drive performance isn't a focus, yet form factor and capacity are, then this is the drive of choice.

★★★½☆

WD Blue PC SSD (M.2 SATA) 250GB

WD's new-old foray into the SSD world.

Western Digital acquired SanDisk last year, resulting in WD entering the SSD marketplace. It made a name for itself doing what it did best – making quality hard disk drives (HDDs) that delivered on performance and durability. Making the shift into memory-related products not only bears risk based on the unfamiliarity of the market and products, but also the manufacturing process and associated financial fluctuations. The WD Blue SATA 6Gbps M.2 SSD is precisely what it says it is – nothing more, nothing less. This simplified naming is refreshing and integrates the SanDisk technology into the WD branding and communication. Based on the SanDisk X400, but with some tweaks, the benchmark results demonstrate the expected read and write performance for a TLC NAND based SSD. Main differences with the Green variant is increased durability, controller capable of higher performance and increased drive capacities.

Verdict

Good value for money built on a trusted pedigree.

★★★★☆

WD Green PC SSD (M.2 SATA) 240GB

WD enters the fracas with a price-conscious offering.

The WD Green SATA M.2 SSD is a budget solution. This unit is best used as an HDD replacement for older systems and a way to bridge an upgrade cycle with the performance benefits of moving to a solid state drive – namely the 'snappy feeling' that an SSD delivers compared to an HDD when placed in an otherwise tired PC that has already done its fair share of computing. With the usage case clear and well understood, the WD Green comes in only two capacities – 120GB and 240GB. Larger sizes, though possible, aren't available in this product line due to the significant influence of price within the mind of the target market. Though it would be possible to create larger drives, the target market isn't looking for these. And with a 240GB drive available for $120, it's easy to understand the approach taken by WD. The WD Green could find itself well suited to the light workloads of a typical HTPC where a small capacity SSD is sufficient and performance doesn't hold a significant influence on experience.

Verdict

As long as you're aware of the shortfalls of the unit and expectations are set appropriately, the WD Green presents good value.

★★★½☆

NEXT-GEN FORM-FACTOR SSD BENCHMARK RESULTS

VENDOR	CORSAIR	INTEL	INTEL	KINGSTON HYPERX*	SAMSUNG
STORAGE PROTOCOL	PCIE NVME	PCIE NVME	PCIE NVME	PCIE NVME	PCIE NVME
MODEL/SERIES NAME	FORCE SERIES MP500	750	600P	PREDATOR PCIE SSD	950 PRO
MODEL NUMBER	CSSD-F120GBMP500	SSDPEDMW012T4	SSDPEKKW512G7	SHPM2280P2/240G	MZ-V5P512BW
PRICE	$149	$1,189	$279	$265	$419
CAPACITY	120GB	1.2TB	512GB	240GB	512GB
DRIVER	INTEL ENTERPRISE (FORCED INSTALL)	INTEL ENTERPRISE	INTEL ENTERPRISE	WINDOWS 10 "IN-BOX" NVME	SAMSUNG NVME V2.1
CDM5 - READ - SEQ. Q32T1 (MB/S)	2,328	2,672	1,825	1,443	2,589
CDM5 - READ - 4K Q32T1 (MB/S)	131.9	134.1	132.5	125.5	132.3
CDM5 - READ - SEQUENTIAL (MB/S)	1,348	1,533	1,123	1,318	2,233
CDM5 - READ - 4K (MB/S)	37.35	33.41	28.6	33.13	41.99
CDM5 - WRITE - SEQ. Q32T1 (MB/S)	1235	1347	563.5	818.5	1530
CDM5 - WRITE - 4K Q32T1 (MB/S)	130.5	130.7	120.4	119.1	129.8
CDM5 - WRITE - SEQUENTIAL (MB/S)	1240	1324	565.6	816.2	1529
CDM5 - WRITE - 4K (MB/S)	89.59	98.4	72.66	74.28	93.59
AS SSD - READ - SEQUENTIAL (MB/S)	1,981.58	2,353.8	1,627.83	1,362.88	2,234.28
AS SSD - READ - 4K (MB/S)	40.24	29.89	26	28.07	36.6
AS SSD - READ - 4K 64 THREAD QUEUE DEPTH (MB/S)	280.65	408.79	356.52	322.09	524.09
AS SSD - READ - ACCESS TIME (MS)	0.048	0.039	0.077	0.058	0.044
AS SSD - READ - SUMMARISED SCORE	519	674	546	486	784
AS SSD - WRITE - SEQUENTIAL (MB/S)	257.42	1327.82	546.61	756.37	1438.46
AS SSD - WRITE - 4K (MB/S)	9.93	76.76	63.13	53.82	72.13
AS SSD - WRITE - 4K 64 THREADS (MB/S)	11.93	398.28	259.68	272.43	417.43
AS SSD - WRITE - ACCESS TIME (MS)	0.337	0.052	0.059	0.072	0.052
AS SSD - WRITE - SUMMARISED SCORE	48	608	377	402	633
AS SSD - OVERALL SUMMARISED SCORE	760	1,583	1,155	1,115	1,788
ASU - OVERALL READ SCORE	3,260.59	3,253.39	2,639.94	2,640.48	4,063.97
ASU - OVERALL WRITE SCORE	342.92	2,042.42	1,305.62	1,511.87	2,219.51
ASU - OVERALL SCORE	3,603.51	5,295.81	3,945.56	4,152.35	6,283.47
ASU - RANDOM READ IOPS (QUEUE DEPTH 128)	27,154.1	26,509.1	25,344.2	25,319.3	25,221.9
ASU - RANDOM WRITE IOPS (QUEUE DEPTH 64)	3,143.7	25,062.6	23,544.9	24,415.6	23,030.9

VENDOR	SAMSUNG	SAMSUNG	INTEL	WESTERN DIGITAL	WESTERN DIGITAL
STORAGE PROTOCOL	PCIE NVME	PCIE NVME	SATA 6GBPS	SATA 6GBPS	SATA 6GBPS
MODEL/SERIES NAME	960 EVO	960 PRO	540S	BLUE PC SSD	GREEN PC SSD
MODEL NUMBER	MZ-V6E500	MZ-V6P512	SSDSCKKW010X6	WDS250G1B0B	WDS240G1G0B
PRICE	$339	$449	$579	$145	$120
CAPACITY	500GB	512GB	1TB	250GB	240GB
DRIVER	SAMSUNG NVME V2.1	SAMSUNG NVME V2.1	INTEL RST 15.2.0.1020	INTEL RST 15.2.0.1020	INTEL RST 15.2.0.1020
CDM5 - READ - SEQ. Q32T1 (MB/S)	3,223	3,530	559.8	562	558.1
CDM5 - READ - 4K Q32T1 (MB/S)	132.1	132.4	120.2	125.6	120.6
CDM5 - READ - SEQUENTIAL (MB/S)	2,017	2,868	522.4	522	537.5
CDM5 - READ - 4K (MB/S)	37.66	42.6	26.98	28.52	22.27
CDM5 - WRITE - SEQ. Q32T1 (MB/S)	1,753	2,133	494.2	535	471.2
CDM5 - WRITE - 4K Q32T1 (MB/S)	130.2	130.2	115.2	120.1	114
CDM5 - WRITE - SEQUENTIAL (MB/S)	1750	2138	482.5	512.4	455.5
CDM5 - WRITE - 4K (MB/S)	96.31	95.64	73.96	49.83	64.8
AS SSD - READ - SEQUENTIAL (MB/S)	2,420.7	2,895.87	506.32	480.82	525.13
AS SSD - READ - 4K (MB/S)	35.98	37.08	24.18	25.79	15.14
AS SSD - READ - 4K 64 THREAD QUEUE DEPTH (MB/S)	507.45	142.84	200.24	183.75	108.11
AS SSD - READ - ACCESS TIME (MS)	0.045	0.046	0.056	0.079	0.061
AS SSD - READ - SUMMARISED SCORE	785	470	275	258	176
AS SSD - WRITE - SEQUENTIAL (MB/S)	1,666.39	2,043.64	444.78	480.61	443.8
AS SSD - WRITE - 4K (MB/S)	73.47	73.76	59.6	43.35	54.94
AS SSD - WRITE - 4K 64 THREADS (MB/S)	322.67	359.37	101.76	107.06	65.82
AS SSD - WRITE - ACCESS TIME (MS)	0.052	0.052	0.059	0.092	0.166
AS SSD - WRITE - SUMMARISED SCORE	563	637	206	198	165
AS SSD - OVERALL SUMMARISED SCORE	1721	1318	627	598	432
ASU - OVERALL READ SCORE	3,707.16	4,276.57	1,347.03	1,456.38	1,319.96
ASU - OVERALL WRITE SCORE	2,489.77	2,853.45	1,172.19	1,154.35	1,086.17
ASU - OVERALL SCORE	6,196.93	7,130.02	2,519.22	2,610.73	2,406.13
ASU - RANDOM READ IOPS (QUEUE DEPTH 128)	25,196.9	25,057	20,394.8	20,427.5	19,964.2
ASU - RANDOM WRITE IOPS (QUEUE DEPTH 64)	24,164.3	24,016.5	19,156.8	20,189.8	17,450.6

CDM5 = CRYSTAL DISK MARK 5.2.0, AS SSD = AS SSD BENCHMARK 1.9.5986.35387, ASU = ANVIL'S STORAGE UTILITIES V1.1.0
* = NOTE TESTS RUN AT DDR4-2133 DUE TO MB-SSD HARDWARE CONFLICT

PS C:\Users\nickd> $profile
D:\Nick\Documents\WindowsPowerShell\Microsoft.PowerShell_profile.ps1
PS C:\Users\nickd> test-path $profile
False
PS C:\Users\nickd> new-item -path $profile -itemtype file -force
Directory: D:\Nick\Documents\WindowsPowerShell
Mode LastWriteTime Length Name
-a---- 10/02/2017 15:46 0 Microsoft.PowerShell_profile.ps1
PS C:\Users\nickd> notepad $profile
PS C:\Users\nickd>
function pro {notepad $profile}
$a = (Get-Host).PrivateData
$a.WarningBackgroundColor = "red"
$a.WarningForegroundColor = "white"
ASUS
HDMI

MASTER THE POWERSHELL

Discover how to get started with Microsoft's powerful scripting tool for Windows with Nick Peers.

At first glance, the Windows PowerShell looks to be a facsimile of the Command Prompt, but to dismiss it as such leaves you missing a huge trick. In fact, PowerShell is a platform designed to automate many Windows tasks through a clever scripting language. It's based on the .NET Framework, which gives it lots of flexibility and scope, particularly when you access it through the PowerShell ISE (Integrated Scripting Environment) program, which provides even more useful tools and shortcuts – such as syntax highlighting and IntelliSense tab completion – to help you build the perfect script to achieve what you want.

If you've already dabbled with the Command Prompt – and .bat batch files in particular – you're already well on the road to getting to grips with PowerShell. Many familiar commands work in PowerShell, too – thanks to a clever aliasing system, you can type a Command Prompt command and it's automatically translated into the correct PowerShell command.

In this article, we're going to introduce you to the PowerShell from the perspective of someone who's not encountered it before, and is interested in discovering what it may or may not be able to do for them. We'll make some fairly basic assumptions – you're aware of how programing and scripting work, for example – but we will start at the beginning, teaching you the fundamental building blocks of PowerShell. In the process, we'll reveal what 'cmdlets' are and how they work, plus you'll discover how to stitch them together to form fully functional commands, gently easing you into the world of scripting. We'll also introduce the basic syntax and structure of the language, while providing you with some real-world examples to try.

You'll find out how to install the latest version of PowerShell in older versions of Windows, discover how to get help, and find some of the best online reference guides. You'll also learn about setting up profiles, and gain useful tips and tricks to help you start to use PowerShell to make your own computing life that bit easier.

Ready to start on the road to becoming a PowerShell guru? Let's go!

We'll begin by opening PowerShell – if you're running Windows 7, 8, or 8.1, check the box over the page to obtain the latest version. Click the Start button, and scroll down the All Apps list until you locate the Windows PowerShell folder. Click this to reveal two (or four if you're running 64-bit Windows) options: 'PowerShell' and 'PowerShell ISE'. Let's start with the basic PowerShell command prompt. Select 'PowerShell'. This launches the application with non-administrative privileges, and places you in your own personal user folder, just like the Command Prompt. Right-click the shortcut and choose 'Run as Administrator'. It places you at C:\Windows\System32. It goes without saying, though, that you shouldn't run PowerShell as an administrator unless you specifically need to. For the purposes of this tutorial, we're going to stick to running it as a regular user, except where stated.

The PowerShell window opens, providing you with a similar – at first glance – interface to the regular Command Prompt. You can customise the view by right-clicking its menu bar and choosing Properties to reveal a tabbed window. The options are broadly identical to the Command

Prompt — use the Font, Layout and Colors tabs to customise its look and feel.

To help you plot a route through potentially maze-like commands, the text changes colour as you type different parts of the command: cmdlets and aliases are yellow, with parameters displayed in white, and flags (switches preceded by the '–' dash symbol) in grey. Variables are displayed in green and text strings in dark blue.

As an aside, you can change these — and other message colours — if you don't like them, but those options are edited using PowerShell commands. We'll look at them in more detail later.

FIRST STEPS

PowerShell is about building blocks. Those blocks are known as "cmdlets." They're called this to differentiate them from commands as used by the Command Prompt. In the Command Prompt, commands either refer to specific programs, such as chkdsk.exe or edit.com, or are "internal commands" related to the main command.com program (for example, "dir" and "mkdir").

Cmdlets work in a different way. PowerShell works through the .NET Framework, so cmdlets are actually instances of .NET Framework classes, not standalone executable files. What this means in practice is that cmdlets rely on PowerShell to handle the parsing of commands, plus provide any error presentation and output formatting.

Furthermore, while commands are designed to work on their own, cmdlets can work in isolation, or be used in combination with others to create more feature-complete commands. Cmdlets can be split into various types, enabling you to mix and match with precision to get the results you need. Indeed, with some practice, you'll be able to build complete applications from just a few dozen lines of code.

CMDLETS UNCOVERED

All cmdlets follow the same structure: verb-noun. So you have 'Get-Alias', 'Clear-History', 'Set-Location' and so on, which helps make them easier to grasp. The verb part of the cmdlet reveals what it's designed to do — for example, 'Get' cmdlets are designed to retrieve data, while 'Set' cmdlets are used to establish or change data. 'Format' cmdlets format data in a particular way, and 'Out' cmdlets are designed to direct your command's output to a specific destination, whether that's the screen, a file or somewhere else.

Many cmdlets have abbreviated aliases, too. These are shortened forms of the cmdlet — for example, 'clhy' refers to 'Clear-History', the command for deleting all entries from the command history. Others link back to the Command Prompt, to make it easier for those with experience of the command line to migrate across to PowerShell. For example, 'cd' refers to 'Set-Location', which is used to change the working directory in PowerShell, while 'dir' is the alias for 'Get-ChildItem', which is used to list the files and folders in the current directory. To list all aliases, use the 'Get-Alias' cmdlet on its own, like so:

```
> Get-Alias
```

Add "alias" to the end, substituting 'alias' with your chosen alias, to get a specific command. For example:

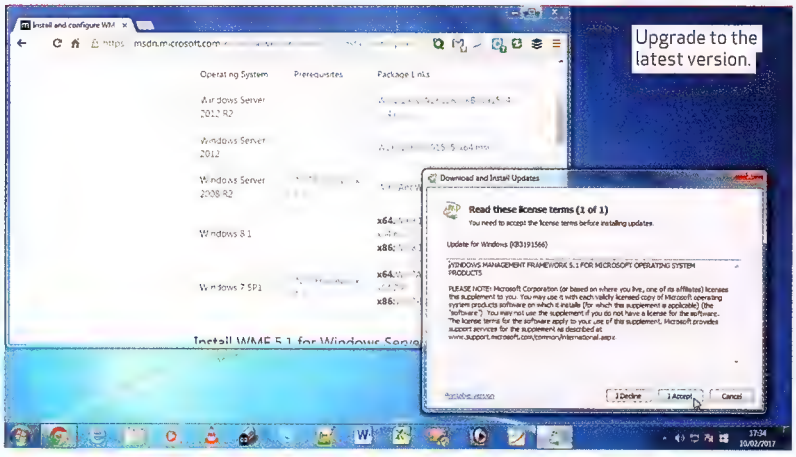
```
> Get-Alias dir
```

To find out more about what specific cmdlets and aliases can do — and see examples of them in action — use PowerShell's help commands. The box on page 73 reveals what you need to know. You can also create your own aliases using the 'function' cmdlet — more on this soon.

USING PARAMETERS

Just like regular Command Prompt commands, cmdlets are controlled using various parameters (also referred to as switches and flags). The Help box on page 73 reveals how to identify what a cmdlet's parameters are and what they do.

PowerShell also supports variables, which should be preceded with a '$' string. Each variable is defined on its own line, and then that variable can be called later on.



Get PowerShell

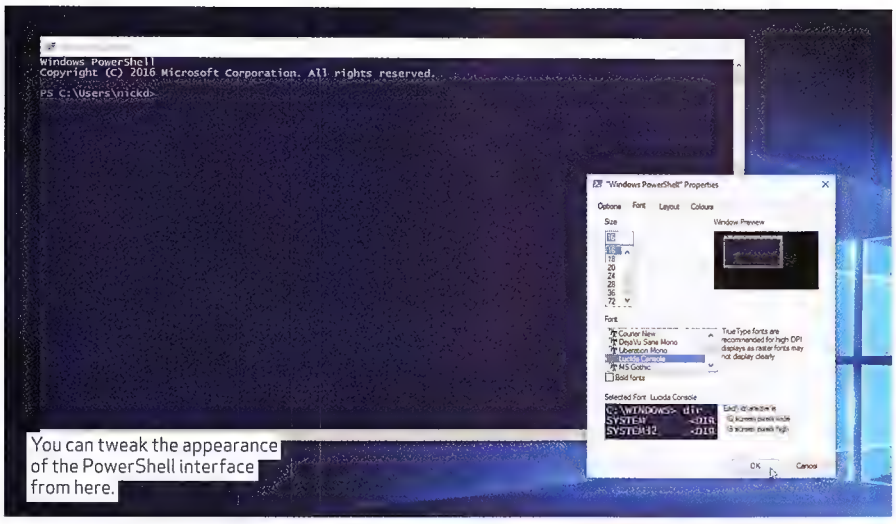
We're featuring the most recent release of PowerShell — version 5.1 — and it comes pre-installed with the latest version of Windows 10. All you need to do is launch it, either from the Start menu's All Apps list, or by typing "powershell" into the Search box. You can then right-click its Taskbar icon and choose 'Pin to Taskbar' for a convenient shortcut going forward.

Windows 8 and 8.1 users currently use PowerShell 4. If you want to upgrade to version 5.1, simply download the correct version — x86 (32-bit) or x64 (64-bit) — from **msdn.microsoft.com/en-us/powershell/wmf/5.1/install-configure**. Double-click it, and follow the installation prompts.

Windows 7 ships with an even older version of PowerShell, dating back to 2009. To upgrade that, you first need to verify the .NET Framework 4.5.2 is installed (a link to it is provided at the site above, or you can install it through Windows Update). Once done, download the relevant x86 or x64 standalone installer file (around 65MB), then double-click it, and again follow the prompts.

Once installed, you're prompted to reboot, so do so, and impatiently wait for Windows to reload. Then it's a case of simply opening PowerShell in the usual way — via the Start menu or by pressing Win-Q in Windows 8 to open the Search charm. The latest version powers up (you can verify this by checking out the copyright notice, which should now read '2016', rather than '2009' or '2012') and you're ready to delve into PowerShell without missing out on all the latest improvements and new features.

To see what's new, click 'New Scenarios and Features' on the download page for version 5.1, and also check out the 'WMF 5.0' link, where you'll discover major features introduced since Windows 7 and 8 were released.

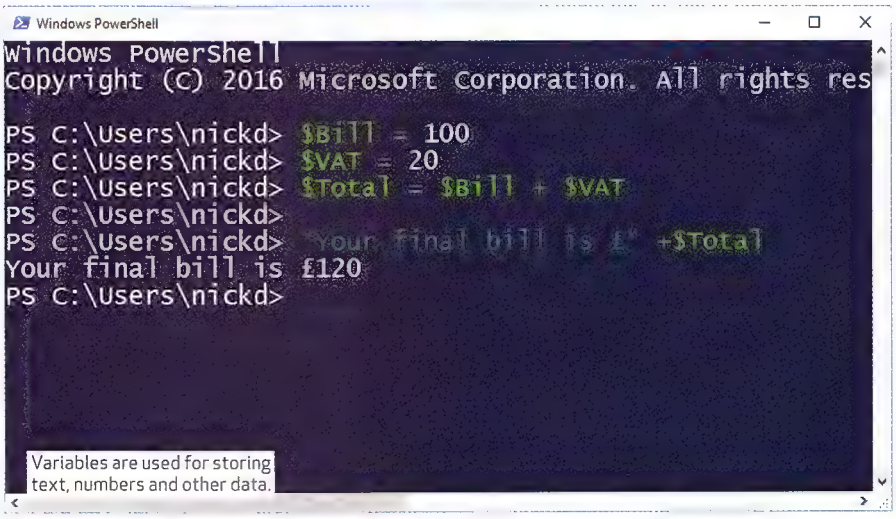

Windows PowerShell
Copyright (C) 2016 Microsoft Corporation. All rights reserved.
PS C:\Users\nickd>
"Windows PowerShell" Properties
You can tweak the appearance of the PowerShell interface from here.

"With some practise, you'll be able to build complete applications from just a few dozen lines of code."

For example, try the following lines:

```
> $Bill = 100
> $TAX = 20
> $Total = $Bill + $TAX
> "Your final bill is"
+$Total
```

As an aside, you could write "Your final bill is $Total" and that would work, too, because PowerShell is smart enough to recognise that $Total is variable. On other hand, if you wanted to write '$Total' as a word and not the variable, use 'Your final bill is $Total' instead. (More on command syntax in a minute.) You'll come across a special variable ($_) that may or may not precede something else, such as '$_.status'. This is a placeholder, and we'll look at it later.


Windows PowerShell
Windows PowerShell
Copyright (C) 2016 Microsoft Corporation. All rights res
PS C:\Users\nickd> $Bill = 100
PS C:\Users\nickd> $VAT = 20
PS C:\Users\nickd> $Total = $Bill + $VAT
PS C:\Users\nickd>
PS C:\Users\nickd> "Your final bill is £" +$Total
Your final bill is £120
PS C:\Users\nickd>
Variables are used for storing text, numbers and other data.

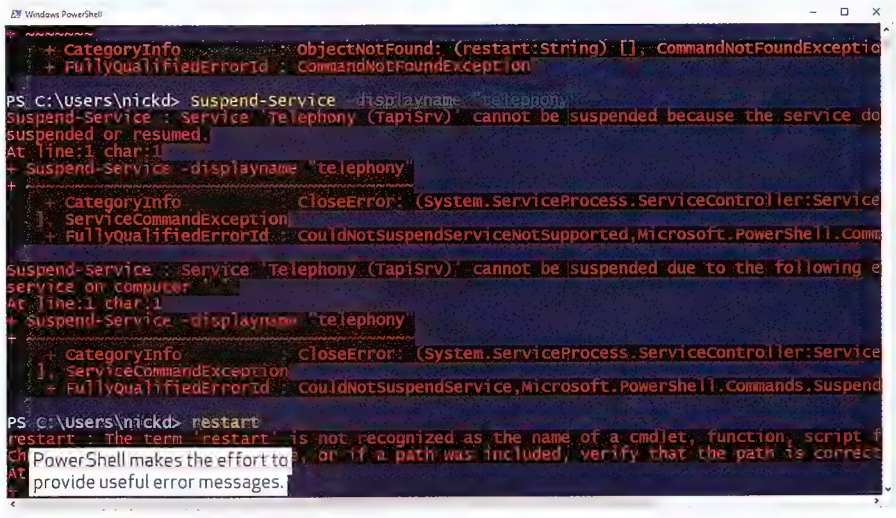
MORE COMMAND SYNTAX

PowerShell uses standard scripting operators to help build commands – everything from commas to separate items in a list, to enclosing text strings in double quotation marks (as you saw earlier, PowerShell is smart enough to identify variables inside quote marks). There are also some handy conditional operators you can use when creating conditional statements. Use '-eq' to mean equals and '-ne' to mean not equal. Enter '-gt' for greater than (and '-ge' for greater than or equal) or '-lt' and '-le' for less than or less than or equal.

The pipe symbol '|' combines two or more commands in a single line of code. It's used to 'pipe' the output of one command so it becomes the input of the next command. If you type 'ping pcgamer.com', you'll see a list of text describing the results – now type the following command:

```
> Ping pcgamer.com | Select-String packets | Out-File tempfile.txt
```

This pings pcgamer.com as before, but this time, it searches the output for lines containing 'packet', then saves them into a tempfile.txt file, which it saves to the current working directory.


Windows PowerShell
+ CategoryInfo : ObjectNotFound: (restart:String) [], CommandNotFoundExceptio
+ FullyQualifiedErrorId : CommandNotFoundException
PS C:\Users\nickd> Suspend-Service -displayname "telephony"
Suspend-Service : Service 'Telephony (TapiSrv)' cannot be suspended because the service do
suspended or resumed.
At line:1 char:1
+ Suspend-Service -displayname "telephony"
+ CategoryInfo : CloseError: (System.ServiceProcess.ServiceController:Service
+ FullyQualifiedErrorId : CouldNotSuspendServiceNotSupported,Microsoft.PowerShell.Comm
Suspend-Service : Service 'Telephony (TapiSrv)' cannot be suspended due to the following e
service on computer
At line:1 char:1
+ Suspend-Service -displayname "telephony"
+ CategoryInfo : CloseError: (System.ServiceProcess.ServiceController:Service
+ FullyQualifiedErrorId : CouldNotSuspendService,Microsoft.PowerShell.Commands.Suspend
PS C:\Users\nickd> restart
restart : The term 'restart' is not recognized as the name of a cmdlet, function, script f
At
PowerShell makes the effort to provide useful error messages.

Open File Explorer to locate the file – it contains a single line of text, something like "Packets: Sent = 4, Received = 4, Lost = 0 (0% loss)".

CONDITIONAL STATEMENTS

Sometimes, you want your commands to process differently depending on whether or not specific conditions are met. Like all good scripting and programing languages, PowerShell supports this through 'If' and 'Else' statements (as well as variants, such as 'ForEach'). The basic structure for conditional commands is this:

```
> If (condition) {perform task if  condition is met or true}
```

You'll see two different types of bracket have been referenced here. Use parentheses (regular brackets) for required options within the loop. Your conditions can include '-And', '-Not' and '-Or' flags to provide more

complex conditions. For example, the following performs the task if either test1 or test2 conditions are met:

```
> If (test1 -Or test2)
{perform task}
```

Replace '-Or' with '-And' and both test conditions would be required; change it to '-Not' and test1 would need to be met and test2 specifically not met for the task to run.

Curly braces can also be used for block expressions within a command that explicitly looks for a condition to be met. For example, the 'Where-Object' cmdlet allows you to filter data returned by other cmdlets, as the following example demonstrates:

```
> Get-Service | Where-Object
{$_.status  -eq "stopped"}
```

This produces a list of services on your PC that aren't currently running. The '$_' placeholder enables you to capture the output of 'Get-Service' without having to run the command again. The 'status' portion of the variable is a specific child property linked to 'Get-Service'. You can find out what these are using the 'Get-Member' command, like so:

```
> Get-Service | Get-Member
```

Last, but not least, you can also use square brackets which represent optional elements that aren't required for a cmdlet to run. For example:

```
> Get-Service [w]*
```

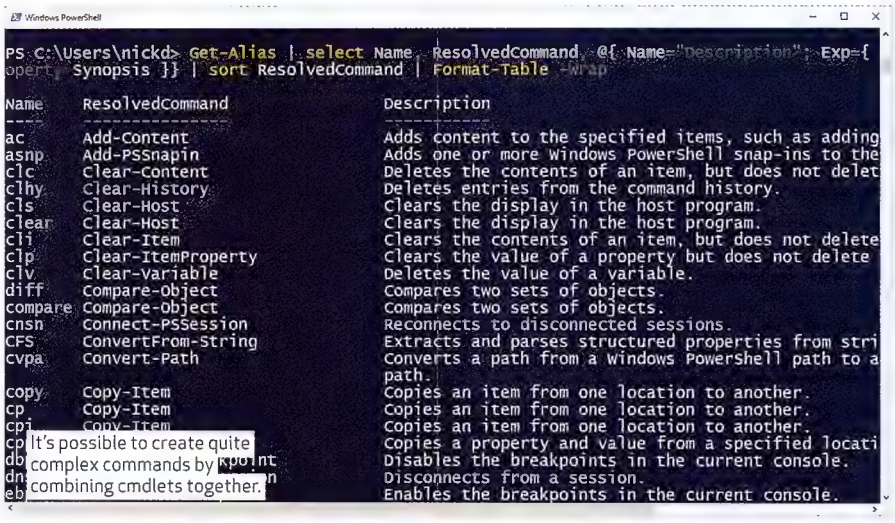
This produces a filtered list of services that begin with the letter 'w'. Square brackets are also used for certain maths functions.

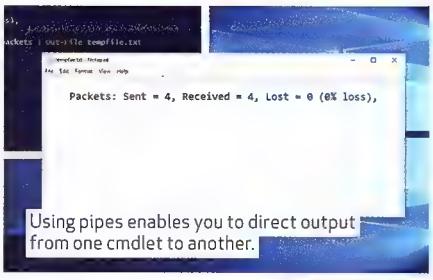
PUT IT ALL TOGETHER

You can combine cmdlets, variables, parameters, and syntax to perform quite complex tasks with what amounts to not very much code. The following example provides a complete list of aliases, their associated cmdlets and available parameters, sorted by cmdlet name rather than alias. Look closely, and you should see some logic – the 'sort' command clearly refers to 'ResolvedCommand' (the cmdlet name), for example, while the 'Get-Help' cmdlet pulls the information about each cmdlet's parameters. Finally, the 'Format-Table' cmdlet is used to output the results neatly over three columns.

```
> Get-Alias | select Name,
ResolvedCommand, @{
Name="Description"; Exp={
Get-Help $_  | Select
-ExpandProperty Synopsis }} |
sort ResolvedCommand | Format-
Table  -Wrap
```

Before we move on, having to type these commands in full can be time-consuming, but here's a handy shortcut: start typing a cmdlet, then press Tab to auto-complete it – if more than one match is found, keep hitting Tab until your cmdlet is displayed and press Shift-Tab to cycle back through the list in case you miss your target.


Windows PowerShell
PS C:\Users\nickd> Get-Alias | select Name, ResolvedCommand, @{ Name="Description"; Exp={
Synopsis }} | sort ResolvedCommand | Format-Table -Wrap
Name ResolvedCommand Description
ac Add-Content Adds content to the specified items, such as adding
asnp Add-PSSnapin Adds one or more Windows PowerShell snap-ins to the
clc Clear-Content Deletes the contents of an item, but does not delet
clhy Clear-History Deletes entries from the command history.
cls Clear-Host Clears the display in the host program.
clear Clear-Host Clears the display in the host program.
cli Clear-Item Clears the contents of an item, but does not delete
clp Clear-ItemProperty Clears the value of a property but does not delete
clv Clear-Variable Deletes the value of a variable.
diff Compare-Object Compares two sets of objects.
compare Compare-Object Compares two sets of objects.
cnsn Connect-PSSession Reconnects to disconnected sessions.
CFS ConvertFrom-String Extracts and parses structured properties from stri
cvpa Convert-Path Converts a path from a Windows PowerShell path to a path.
copy Copy-Item Copies an item from one location to another.
cp Copy-Item Copies an item from one location to another.
cpi Copy-Item Copies an item from one location to another.
cp Copies a property and value from a specified locati
db Disables the breakpoints in the current console.
dn Disconnects from a session.
eb Enables the breakpoints in the current console.
It's possible to create quite complex commands by combining cmdlets together.



HANDY CMDLETS

Let's introduce some more cmdlets. An exhaustive A-Z list is beyond us, so bookmark the 'Task-Based Guide to Windows PowerShell Cmdlets' at **https://technet.microsoft.com/en-us/library/dd772285.aspx**. It's organised into tasks under such groups as 'Dates and Times', 'Files and Folders', 'Help and Information', 'Scripting Techniques' and 'System Administration Tasks'.

First up, the 'Get-Date' cmdlet lists the date and time – use the '-displayhint' parameter, and specify either date or time to filter the output. You can also use 'Get-Date' to specify a variable using date/time format and to perform various forms of time- or date-based arithmetic, using such parameters as 'AddSeconds' through to 'AddYears'. The following is a handy way to quickly calculate time offsets for different parts of the world:

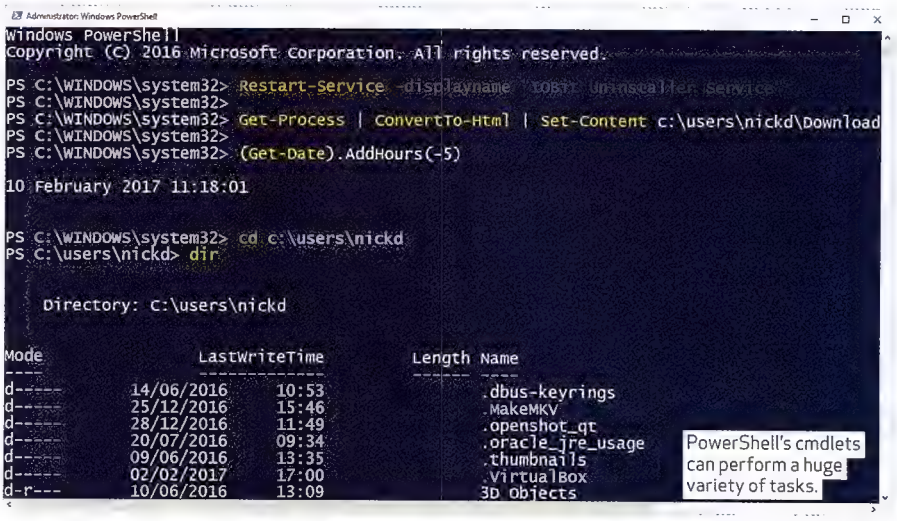
```
> (Get-Date).AddHours(-5)
```

Next, use 'Copy-Item' to copy files or folders to a new location – you need to specify the source, then the destination. Use the wildcard (*) character to copy all files in a folder to the location or *.doc to restrict it to copying only specific file types:

```
> Copy-Item c:\users\nickd\
documents\ scripts\*.ps1 c:\
users\nickd\downloads\test\
```

Related file-based cmdlets include 'Remove-Item' (delete), 'Move-Item', 'Rename-Item' and 'New-Item' (create a file or folder – use the '-type' parameter to specify 'file' or 'directory', respectively).

We've touched on using 'Out-File' to record a command's output to a text file, but what if you want to append a string of text to an existing file, instead of creating one? The 'Add-Content' cmdlet does just that. By default, it appends your string immediately after the last character in the file, but it's likely you'll want


Administrator: Windows PowerShell
Windows PowerShell
Copyright (C) 2016 Microsoft Corporation. All rights reserved.
PS C:\WINDOWS\system32> Restart-Service -displayname "COM+ Unmscalfen Service"
PS C:\WINDOWS\system32>
PS C:\WINDOWS\system32> Get-Process | ConvertTo-Html | Set-Content c:\users\nickd\Download
PS C:\WINDOWS\system32>
PS C:\WINDOWS\system32> (Get-Date).AddHours(-5)
10 February 2017 11:18:01
PS C:\WINDOWS\system32> cd c:\users\nickd
PS C:\users\nickd> dir
Directory: C:\users\nickd
Mode LastWriteTime Length Name
d----- 14/06/2016 10:53 .dbus-keyrings
d----- 25/12/2016 15:46 .MakeMKV
d----- 28/12/2016 11:49 .openshot_qt
d----- 20/07/2016 09:34 .oracle_jre_usage
d----- 09/06/2016 13:35 .thumbnails
d----- 02/02/2017 17:00 .VirtualBox
d-r--- 10/06/2016 13:09 3D Objects
PowerShell's cmdlets can perform a huge variety of tasks.

Windows PowerShell
PS C:\Users\nickd> help cd
Updating help for module ditrucker
Set-Location -LiteralPath <string> [-PassThru] [-UseTransaction] [<CommonParameters>]
Set-Location [-PassThru] [-StackName <string>] [-UseTransaction] [<CommonParameters>]
ALIASES
sl
cd
chdir
REMARKS
Get-Help cannot find the Help files for this cmdlet on this computer. It is displaying only partial help.
To download and install Help files for the module that includes this cmdlet, use Update-Help.
To view the Help topic for this cmdlet online, type: "Get-Help Set-Location -Online" or
go to http://go.microsoft.com/fwlink/?LinkID=113397.
PS C:\Users\nickd> update-help
Download the latest help files.

Get help

There's plenty of help — offline and on — waiting for you with PowerShell. The obvious place to start is with its own built-in help tools. Type the following:

```
> help cmdlet
```

Replace 'cmdlet' with your cmdlet's or alias's name. You'll receive a prompt that the more detailed help files require installing, but to avoid a string of error messages, first close and restart PowerShell as an administrator, then type:

```
> Update-Help
```

A green progress bar appears, and then the files are added, one module at a time — don't be surprised to end with an error message or two, which can be safely ignored. Close and restart PowerShell again.

Now the help files have been replaced, use the following command:

```
> Get-Help cmdlet
```

You can add some handy parameters. '-detailed' ('Get-Help cmdlet -detailed') provides a list of all available parameters for that cmdlet, plus examples of them in action. Use '-examples' if you only want to view examples. One downside of the help file is that you need to keep scrolling back to reference it; add '-online' and it opens in your browser, enabling you to view it side-by-side while coding.

You'll also find lots of websites providing you with more help and advice, too. One of our favourites can be found at **www.computerperformance.co.uk/powershell** — although written for an older version of PowerShell, its basic advice holds true, and it provides a good reference guide, with a handy, if labyrinthine, navigation panel. There's a useful A-Z reference of cmdlets at **ss64.com/ps** and don't forget to check Microsoft's Developer Network at **msdn.microsoft.com/en-us/powershell** for lots more resources — go to 'Documentation > Windows PowerShell' for a detailed introduction.

include 'Start-Service', 'Stop-Service', 'Restart-Service', 'Suspend-Service' and 'Resume-Service'. These need to be followed by the service's name as stored in the Registry — if you don't know this, use the '-displayname' parameter, in conjunction with the name of the service, as it appears under services.msc:

```
> Restart-Service -displayname "File  History Service"
```

Note, you may see an error message appear if you attempt to pause the vast majority of services that don't support being paused and resumed. That's normal, and like all PowerShell error messages, there's usually enough information provided to help you grasp what's going on.

BUILD A COMMAND

We've touched on how cmdlets work best when used in conjunction with others to form complete commands. Here's a practical example of how to use PowerShell to change the message colours it displays, with the help of the 'Get-Host' cmdlet. Start by typing the following, to see how PowerShell currently displays warning messages:

```
> Write-Warning "Alert!"
```

You'll see the message is displayed as yellow text on a black background, which is fine, unless you've modified the background and font colours, as outlined earlier. So how do you go about changing it? Easy. We use the 'Get-Host' cmdlet to extract the current properties of the command window using its 'PrivateData' property (which is anything but private — oh the irony):

```
> $a = (Get-Host).PrivateData
> echo $a
```

This reveals no fewer than 10 child properties for 'PrivateData', including two referring to warning colours. We can then change these, like so:

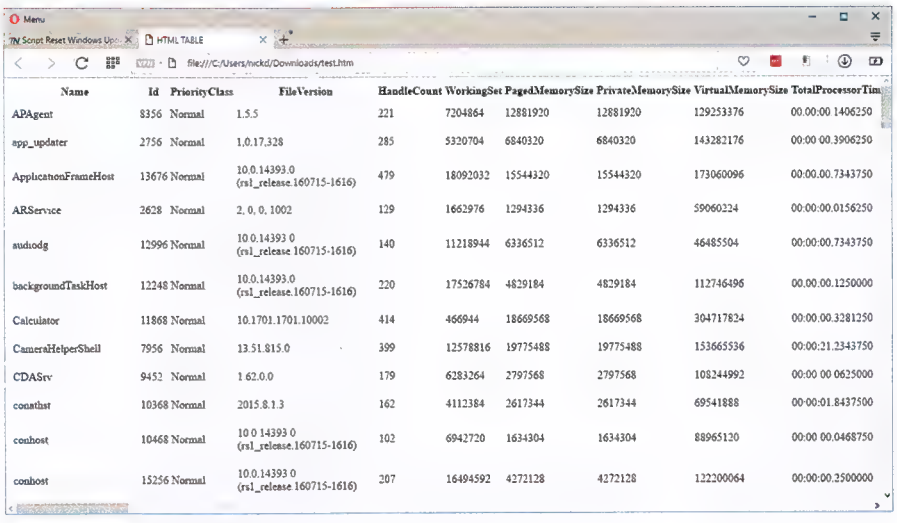
to append it to a new line, so precede your text with `n, like so:

```
> Add-Content c:\users\nickd\ documents\text.txt "`nThe End"
```

Want to output your command to a web page? Use the 'ConvertTo-Html' cmdlet in a piped command, in conjunction with a 'Get-' command and 'Set-Content' (which does the actual writing of data):

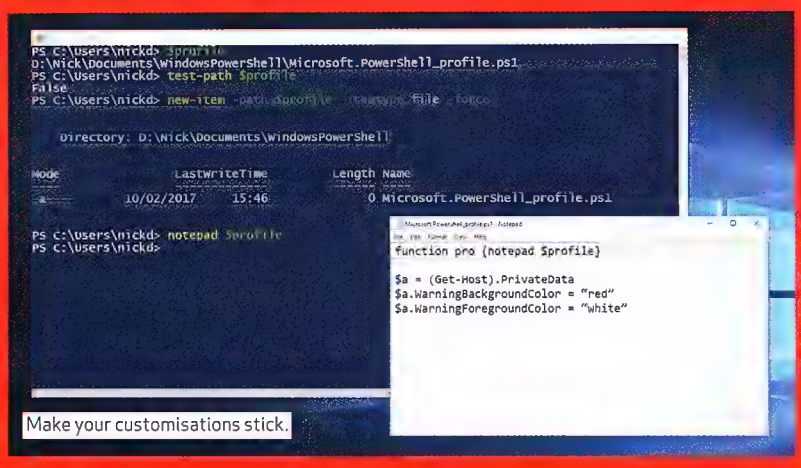
```
> Get-Process | ConvertTo-Html | Set- Content c:\user\nickd\downloads\test.htm
```

PowerShell can be used to manipulate services (and processes), using a number of different cmdlets. Available commands — all self-explanatory, and requiring you to run PowerShell as an administrator —



Name	Id	PriorityClass	FileVersion	HandleCount	WorkingSet	PagedMemorySize	PrivateMemorySize	VirtualMemorySize	TotalProcessorTim
APAgent	8356	Normal	1.5.5	221	7204864	12881920	12881920	129253376	00.00:00.1406250
app_updater	2756	Normal	1.0.17.328	285	5320704	6840320	6840320	143282176	00:00 00.3906250
ApplicationFrameHost	13676	Normal	10.0.14393.0 (rs1_release.160715-1616)	479	18092032	15544320	15544320	173060096	00.00.00.7343750
ARService	2628	Normal	2, 0, 0, 1002	129	1662976	1294336	1294336	59060224	00:00:00.0156250
audiodg	12996	Normal	10 0.14393 0 (rs1_release 160715-1616)	140	11218944	6336512	6336512	46485504	00:00:00.7343750
backgroundTaskHost	12248	Normal	10.0.14393.0 (rs1_release.160715-1616)	220	17526784	4829184	4829184	112746496	00.00.00.1250000
Calculator	11868	Normal	10.1701.1701.10002	414	466944	18669568	18669568	304717824	00:00:00.3281250
CameraHelperShell	7956	Normal	13.51.815.0	399	12578816	19775488	19775488	153665536	00:00:21.2343750
CDASrv	9452	Normal	1 62.0.0	179	6283264	2797568	2797568	108244992	00:00 00.0625000
conathst	10368	Normal	2015.8.1.3	162	4112384	2617344	2617344	69541888	00:00:01.8437500
conhost	10468	Normal	10 0 14393 0 (rs1_release.160715-1616)	102	6942720	1634304	1634304	88965120	00:00 00.0468750
conhost	15256	Normal	10.0.14393 0 (rs1_release 160715-1616)	207	16494592	4272128	4272128	122200064	00:00:00.2500000

The 'ConvertTo-HTML' cmdlet is crude, but effective nonetheless.



Make your customisations stick.

Build a profile

By default, everything you set up in PowerShell — variables, functions, and other customisations, such as the color of warning messages — is lost when you close the current session. If you'd like to preserve this across multiple sessions, you need to create a profile. First, display the path to the Windows PowerShell profile by typing:

```
> $profile
> test-path $profile
```

This reveals that the profile will reside in your Documents folder, while the second command returns a value of 'False', indicating that the profile doesn't yet exist. To create a profile, type:

```
> new-item -path $profile -itemtype file -force
```

To open it in Notepad, type:

```
> notepad $profile
```

A blank document is opened, ready for you to record your variables and other customisations. For example, to change the warning message as outlined in the main text, add the following three lines of code:

```
$a = (Get-Host).PrivateData
$a.WarningBackgroundColor = "red"
$a.WarningForegroundColor = "white"
```

Add the following line, and you can edit your profile simply by issuing the command 'pro' into PowerShell going forward:

```
function pro {notepad $profile}
```

Save the file in Notepad, then close and reopen PowerShell — your customisations should be in place. It basically works like a script file, but is loaded each time you launch PowerShell. It only affects PowerShell when you run it as the current user — if you want to create a profile that affects all users and shells, simply launch PowerShell as an administrator instead. The profile is stored inside the Windows\System32 folder, and applies to all users of your PC.

```
> $a.WarningBackgroundColor = "red"
> $a.WarningForegroundColor = "white"
```

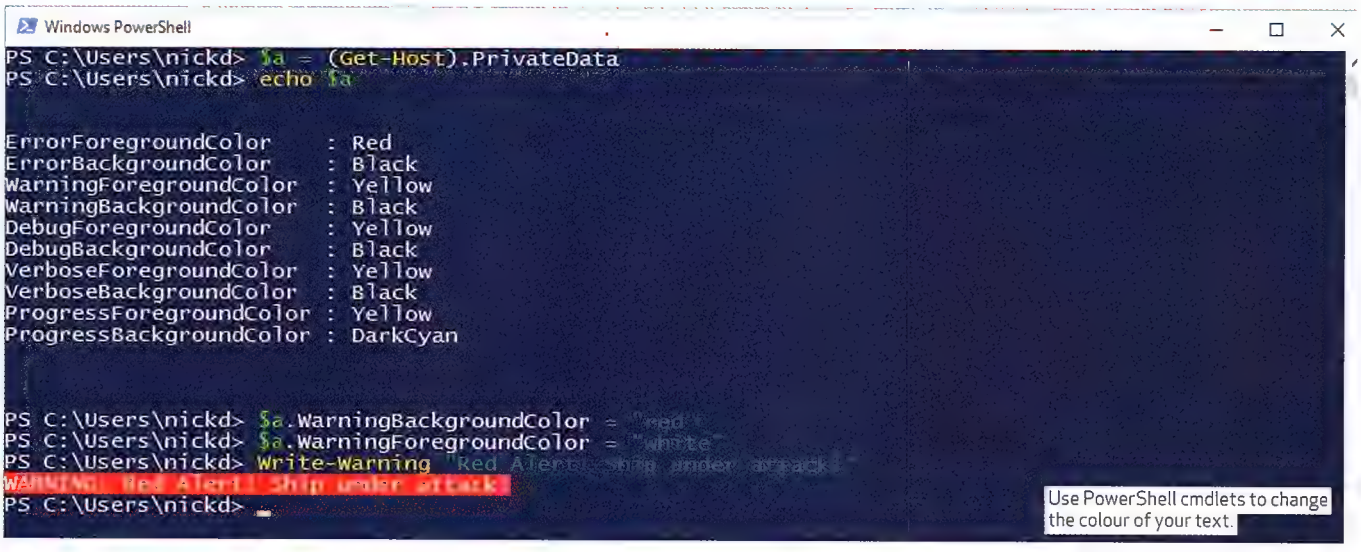
Now try the 'Write-Warning' cmdlet again. Note, however, that the changes won't survive the current PowerShell session — close the window and open it again, and you're back to the original settings. This leads us on to the concept of PowerShell profiles (see left).

BUILDING SCRIPTS

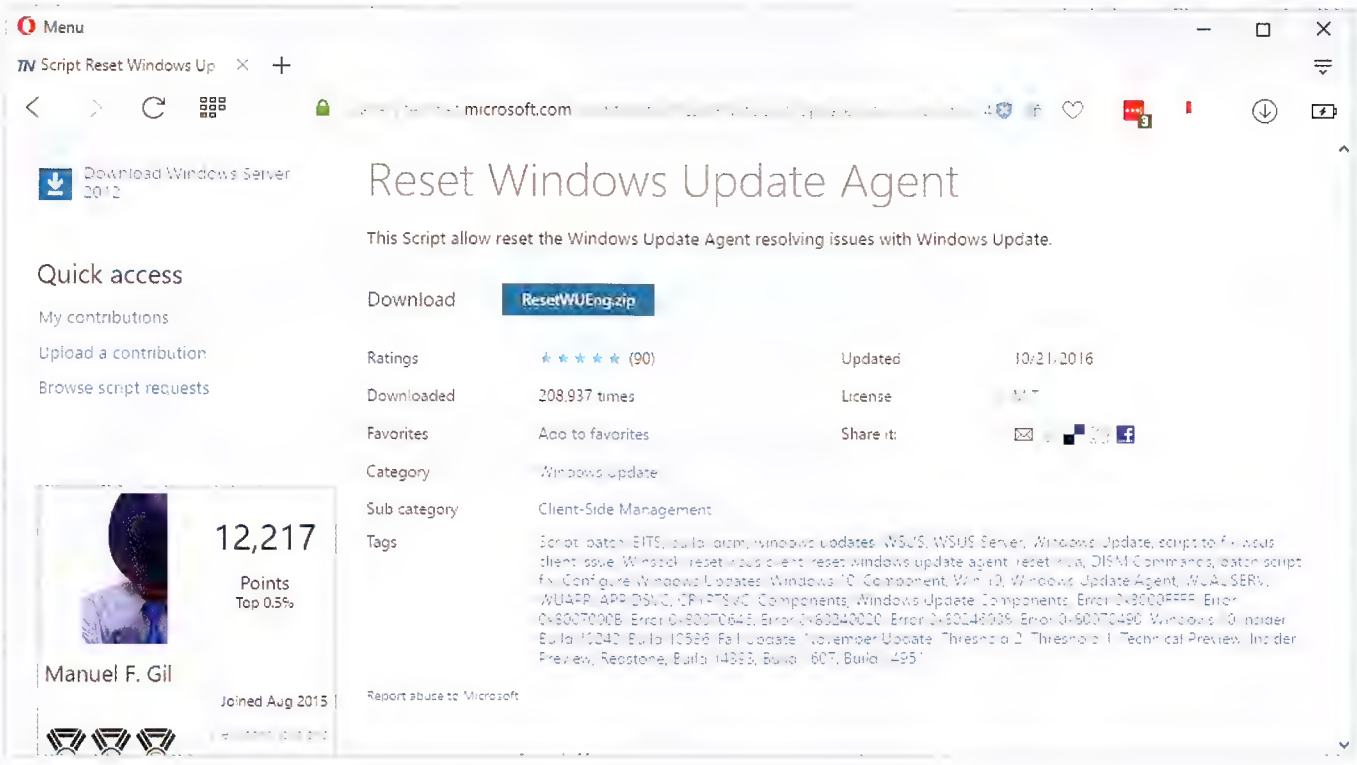
Scripting is a way of storing and running multiple commands from a single file. Command Prompt scripts are written as plain text files, and saved using the .bat extension. Each command is placed on a separate line and run in sequence when the batch file is called from the Command Prompt by navigating to the directory the script is stored in, typing its name (such as 'script.bat') and hitting Enter.

PowerShell supports scripts, too — again, these are text files, but they're stored using the .ps1 file extension. They're called from the PowerShell command prompt — if your script resides in the same directory you're

"While you can create scripts by hand in a text editor, Windows provides all the tools you need to build and test .ps1 scripts in PowerShell ISE."



Use PowerShell cmdlets to change the colour of your text.



currently in, use the following:

```
> .\filename.ps1
```

If you need to call it from another directory, use the following syntax:

```
> & "c:\users\nickd\script.ps1"
```

The first time you attempt this, you'll receive an error message telling you that scripts can't be run. This is down to PowerShell's security policy, which is set to 'Restricted' by default. You can change this policy within PowerShell, but you need to exit and relaunch it as an administrator to do so. Once done, type the following:

```
> Set-ExecutionPolicy -ExecutionPolicy RemoteSigned
```

Press 'Y' and hit Enter when prompted, then try running your script again. This time, it should work – 'RemoteSigned' basically allows all local scripts, as well as downloaded scripts that have been signed by a trusted publisher, to run.

While you can create scripts by hand in a text editor, Windows provides all the tools you need to build and test .ps1 scripts in PowerShell ISE (see right), which provides a more fully rounded experience, plus it's geared toward making it easier and quicker to write, test and run scripts.

You've now started on your journey to tapping into scripting using PowerShell and PowerShell ISE. We've barely scratched the surface, but you should have enough of a grounding to strike out on your own. To help you move on to the next level, visit **gallery.technet.microsoft.com/ScriptCenter**, where you'll find thousands of script resources for PowerShell. They've technically been written for IT professionals, but you'll find plenty of examples that you can make use of as a regular user, too – for example, the 'Reset Windows Update Agent' script enables you to attempt to fix problems with Windows Update from the PowerShell interface.

One final use for PowerShell (run as an admin) is to remove Windows Store apps from your PC. Use the following:

```
> Get-AppxPackage *appname* | Remove-AppxPackage
```

Substitute 'appname' with the name of the app you wish to remove, and they're all up for grabs, even built-in apps ignored by Apps & Features. To get a full list, use:

```
> Get-AppxPackage -AllUser | Format- List -Property PackageFullName
```

PowerShell ISE

Once you've got to grips with the basics, we recommend switching to coding, and developing scripts using PowerShell ISE (search for 'ISE' in the Windows search box). It opens to a multi-pane window: the console window appears to mimic the basic PowerShell interface, but comes with some hidden extras. First, you can input and edit multiple lines of code at once — hit 'Shift-Enter' to add an extra line.

Second, as you start typing cmdlets, the Snippets feature automatically suggests commands to enter (select them with the arrow keys, then a list of supported parameters for the selected cmdlet is displayed; press Tab to insert the cmdlet). Right-click the console window, and choose 'IntelliSense' for an even more helpful tool that suggests parameters, parameter values, and even files and folders.

You'll see a functional menu bar with lots of options related to scripting, and the elusive script window can be brought into view by pressing 'Ctrl-R'. Snippets and IntelliSense work inside here, too, and you can run all your script by pressing F5, plus save it to disk for future use. You can also run just a small portion of it — select the code in question, then hit F5 to run it in isolation from the rest of your script.

The Command panel on the right offers an alternative, interactive way of inserting cmdlets. Select one from the list for a description, then click 'Insert' to insert it into your console, or click the 'Show Details' to view all available parameters. Select one or add in any required information, then click 'Insert' to insert a fully formed command into the console.

Finally, you can expand ISE's capabilities by choosing 'Add-Ons > Open Add-Ons Website' to browse community-written snippets that add different types of functionality to ISE.

how to

» QUICK TIPS

Experts solve your computing problems

APC and its readers can be one giant helpdesk. If you have a technical problem, chances are one of us can solve it.

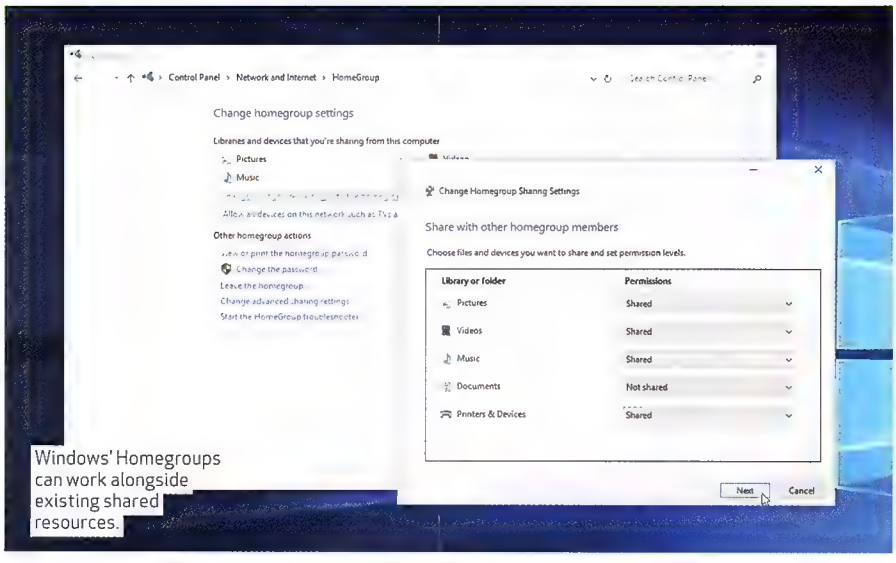
NETWORKING

DO I NEED A HOMEGROUP?

What's the purpose of a Homegroup, and does it prevent my non-Windows devices from being able to access shared content on my Windows 10 PC?
Phillip Renton

You can run a Homegroup side-by-side with traditional shared folders, Phillip. This means you can set up a Homegroup to simplify printer, media and file sharing with other Windows PCs on your network without locking out Macs and other non-Windows devices.

Think of the Homegroup as a simplified set of user permissions, granting Homegroup members easy access to your Libraries, USB-connected printers and media libraries. In addition, you can share other files and folders quickly by right-clicking them and choosing 'Share With'. Other computers, such as Macs, can access your Homegroup's shared content by logging on with your Windows user account credentials, and you can also continue to share folders and files with selected individuals, in addition to your Homegroup (choose 'Specific people...' from the 'Share With' menu).
Nick Odantzis



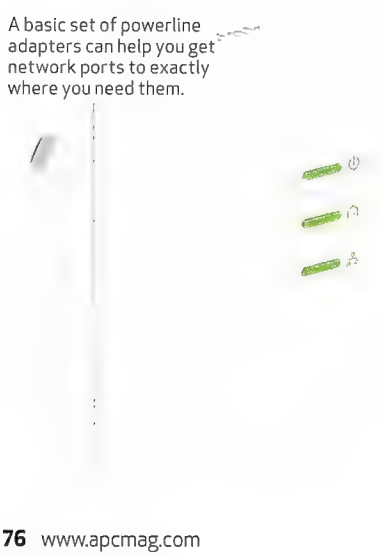
Windows' Homegroups can work alongside existing shared resources.

HARDWARE

MFD ISSUE AFTER UPGRADE

I have a Canon i-Sensys MF8030 multi-function printer/scanner, and had trouble getting it to work properly when connected via USB after updating to Windows 10. In the end I had to connect it to my router and use the network. It works fine, but I'm about to switch to a fibre connection and the new router will no longer be on my desk. How can I keep it hooked up to the network without a direct physical connection to the router?
Evie King

It's possible the problem with the USB connection is that the Windows 10 driver for this model provides only basic functionality, in which case, keeping it connected to the network is the best solution. The simplest option here would be to invest in a pair of HomePlug 'Ethernet over powerline' devices, which allow you to extend your network using your home's electrical circuits. There's a wide variety of options out there, but in this case, we'd recommend a 500Mbps set. Because the MF8030 only has a 10/100Mbps network port, there's no need to pay a premium for a HomePlug with a Gigabit Ethernet port, so expect to pay around $80 for the pair.
Matt Hanson


A basic set of powerline adapters can help you get network ports to exactly where you need them.

WINDOWS

SET UP PC FOR MULTI-PURPOSE COMPUTING

I have a long history of way too many programs being installed on my computers, and this obviously makes them particularly slow and buggy. In general, these programs fall into three or four categories: work, writing, graphics and play. I'm thinking of making an ISO file of the basic computer, then creating separate ISO files for each category of use, switching between them when necessary. Does that make any sense or is there something a lot better? What would you recommend doing?
Marshall Brown

Investing in a low-cost SSD is an easy way to speed up an ageing PC.

We like the idea, but it's not really that practical. It would involve either using drive images and switching between them, or setting up a complicated multi-boot system, with four separate Windows installs, each one focusing on a different category. Neither is a practical or guaranteed solution to your problems. What would work better is investing in boosting your PC's overall performance.

Double its RAM (8GB should be adequate even for demanding systems) and – crucially – invest in a fast 120GB SSD drive on which Windows and your programs can reside, keeping your existing drive as storage for data and other files. This twin performance boost should make your PC easily capable of handling your demands, without requiring any complicated setup.

Graham Barlow

WINDOWS
CANNOT GET INTO MICROSOFT STORE

I followed your advice in APC 430 (see page 74) to fix problems with the Start menu by successfully removing Dropbox. However, since doing this, I can't sign into my Microsoft Account and, therefore, can't get into the Microsoft Store because of this. Can you help?

Marsha Thalin

Marsha was logged into Windows as a local user, but attempting to log into her Microsoft Account via 'Settings > Accounts > Your email and accounts' had no discernible effect. However, during the course of conversation, it became clear that the problem was actually with the Microsoft Store, which would no longer open.

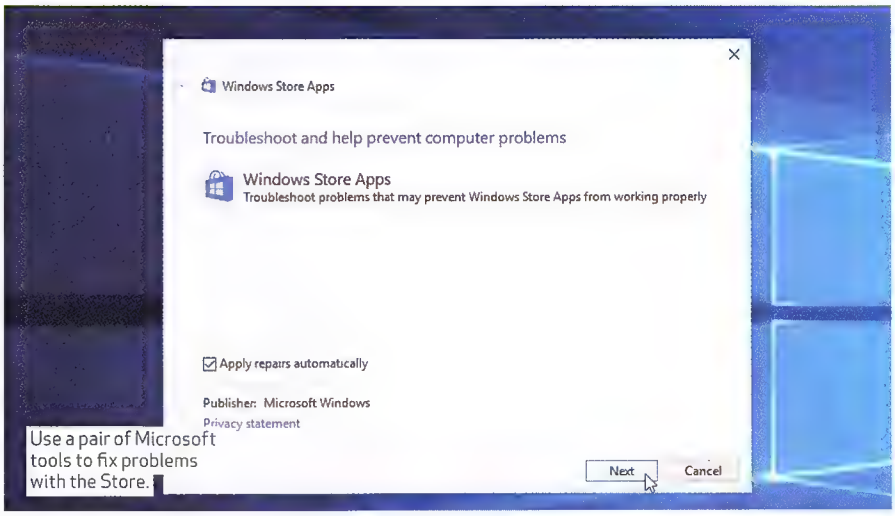
We pointed Marsha to a pair of troubleshooting apps from Microsoft – download them directly from **aka.ms/diag_apps10 and http://aka.ms/diag_cssemerg7008**. Marsha reported that, once she'd run both tools, the Microsoft Store was working correctly again.

Graham Barlow

STORAGE
RECOVER DRIVES FROM DEAD PC?

My Windows 10 PC has died on me. Inside it are two hard drives with files I want to transfer to a new PC. I've been told this is complex and am now concerned my attempts to retrieve the information could lose the data.

Harold Haywood



Use a pair of Microsoft tools to fix problems with the Store.

Harold confirmed the PC was completely dead – no boot messages at all. This is potentially good news, as it should mean the drives inside are physically fine. Once you've identified their size, you'll need to purchase an external drive enclosure to house them in – a cheap USB 3.0 model costs around $30 online. Then simply extract the drive, fit it into the new enclosure and plug it into a working PC.

The drive should be recognised and mounted as an additional drive with all its data intact. You're likely to get an 'Access Denied' error when attempting to open certain folders, such as your own personal user folders, which you'll find inside the Users folder on the root of the drive. If this happens, then click 'Continue' when prompted and Windows should give your current user read and write access to the drive, allowing you to browse and recover files easily.

Nick Peers

WINDOWS
HOW CAN I CREATE REINSTALL MEDIA?

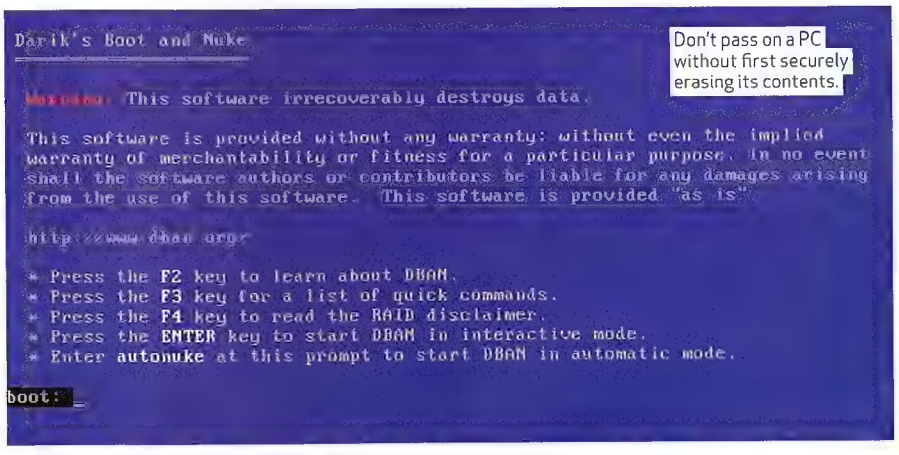
I have to dispose of three PCs, all upgraded from Windows 7 to 10, and tried to follow some online Windows 10 reinstall guides with no success. The problem appears to be I have no recovery environment to fall back on, and neither can I create a recovery drive due to missing files. Any ideas on how to resolve this?

Philip Crowe

The simplest way to create media for reinstalling Windows 10 is via the Media Creation Tool. In this case, when you launch the tool, be sure to select 'Create installation media for another PC'. If all your PCs are running the same system architecture, then the default choices are fine. Choose whether or not to burn to DVD or copy to a USB flash drive (8GB or larger – all existing data will be wiped).

Once it's created, simply boot from this media and follow the prompts to wipe your drive clean and reinstall Windows from scratch, skipping the product key prompt (Windows 10 will automatically reactivate without this). Once complete, your PC will be ready to pass on – but if there's sensitive data on the drive, we recommend using a tool such as DBAN (**www.dban.org**) to securely wipe the drive before you reinstall Windows on it.

Nick Peers


Darik's Boot and Nuke
WARNING: This software irrecoverably destroys data.
This software is provided without any warranty; without even the implied warranty of merchantability or fitness for a particular purpose. In no event shall the software authors or contributors be liable for any damages arising from the use of this software. This software is provided "as is".
http://www.dban.org/
* Press the F2 key to learn about DBAN.
* Press the F3 key for a list of quick commands.
* Press the F4 key to read the RAID disclaimer.
* Press the ENTER key to start DBAN in interactive mode.
* Enter autonuke at this prompt to start DBAN in automatic mode.
boot:
Don't pass on a PC without first securely erasing its contents.

Secure your Windows backups with nCrypted Cloud

Discover how to add a much-needed extra layer of security to your data with Nick Peers.

Ever wondered just how secure your data is when you upload it to the cloud? Providers such as OneDrive and Dropbox make a big song and dance about the fact your data is encrypted, but who holds the all-important encryption keys? If those keys are stored with your data, as is the case with most cloud providers, it leaves one glaring weakness in your secure backup plan.

If you're serious about protecting your data, you need to add extra layers of encryption to it that aren't left in the hands of your cloud storage provider. nCrypted Cloud separates your encryption keys from your data, and one of those keys (the UPK – or User Personal Key) never leaves your client devices. Your cloud provider has no access to your key, and nCrypted Cloud has no physical access to your data, neatly closing that particular security loophole.

nCrypted Cloud works with all major cloud providers, and tucks in lots of useful tools and features to keep inconvenience down and security up. Read on to discover how to add a much-needed extra layer of security to your data.

1 FIRST STEPS

Make sure you've installed the software for your chosen cloud service(s) before you set up nCrypted Cloud. It supports five major providers: Dropbox, Google Drive, OneDrive, Box and Egnyte. Head over to **www.encryptedcloud.com/apps**, where you'll find a link for the Windows client. Click and save the installer to your hard drive, then double-click the setup file, and follow the prompts [**Image A**]. File Explorer will restart, so don't panic when the screen temporarily goes black. Once complete, leave 'I don't have an nCrypted Cloud account' selected, and click 'Next'.

Fill in the form, ignoring the prompt for a work email at the bottom. Remember, make sure your password is strong (but memorable – forget this and your data is toast), then check the terms of service box. Click 'Next' and wait while a recovery key is generated.

When prompted to enter your organisation's name, click 'Skip', followed by 'Finish'.

2 TWEAK INITIAL SETTINGS

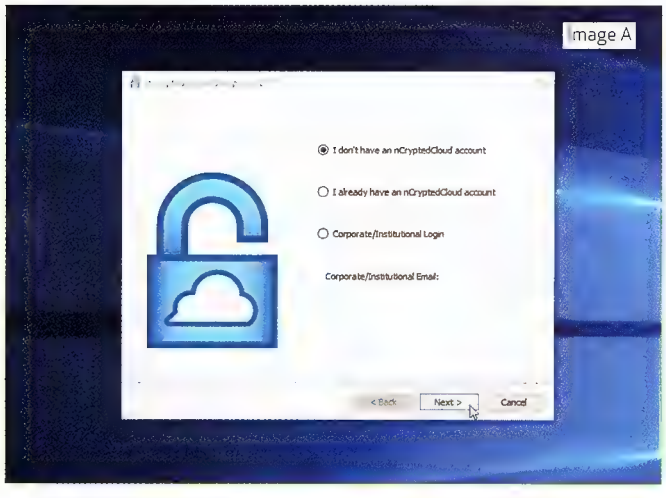
nCrypted Cloud scans your PC for any recognised cloud providers, and automatically links to them – you'll see a File Explorer window open, pointing to the nCrypted Cloud folder, inside which are shortcuts to each cloud provider. Don't panic – nCrypted Cloud hasn't started encrypting any files yet, so before you go further, review which providers have been linked, and verify you're happy with the choices made.

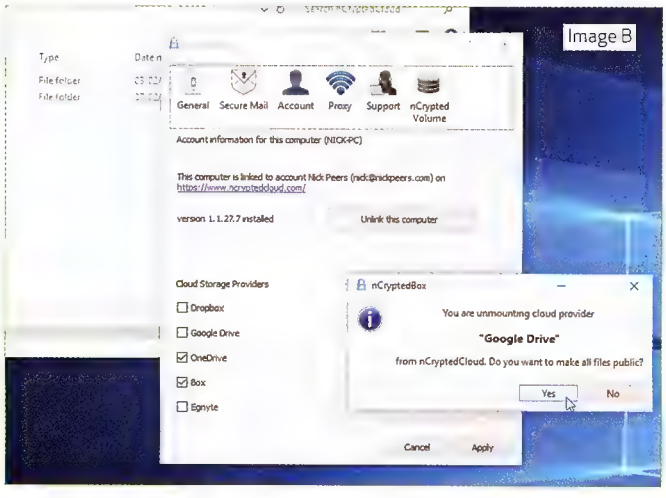
If you want to exclude any, look in the Taskbar's Notification area for the nCrypted Cloud blue padlock-like icon. Right-click this, and choose 'Preferences' to access the main Settings screen. Switch to the Account tab, where you'll see a list of providers [**Image B**] – simply deselect those you wish to exclude, and click 'Apply'. You're prompted to confirm each change by clicking 'Yes', then entering your nCrypted Cloud's username and password.

3 ENCRYPT YOUR FIRST FOLDER

You're ready to add that extra layer of protection to your cloud-hosted data. To see how it works, enter your cloud folder in File Explorer and locate a small folder. Right-click it and choose 'Make Private', clicking 'Yes' when prompted. You'll see a progress bar as nCrypted Cloud encrypts the folder using AES 256-bit encryption, then the folder icon refreshes to show a blue padlock. This padlock is added to each file and subfolder inside the folder, too, making encrypted files easy to identify.

Once complete, your cloud provider app should detect the change and upload the encrypted content to your cloud storage, overwriting the unprotected files. To verify this, right-click your cloud storage app's Taskbar Notification area icon, and choose 'View online' (or similar) to access it through your web browser. Each file is now encrypted as a zip file, and is accompanied by an 'nCrypted Cloud Readme' file. Click this to be told the



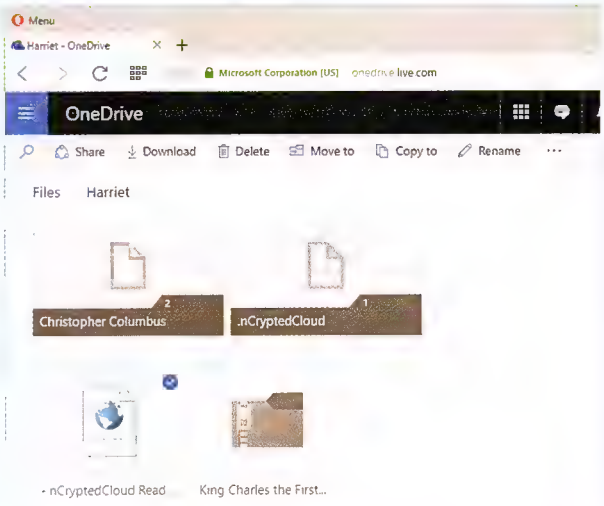


How data is encrypted

nCrypted Cloud stores your data in compressed zip format, protected by industry standard AES-256 encryption. The universal nature of zip means there are plenty of tools — 7-Zip (**www.7-zip.org**), for example — that can read, decrypt (with the right password) and extract the contents if necessary. The password in question isn't your nCrypted Cloud password; it's generated using nCrypted Cloud's own key management system.

This consists of two keys: UPK (User Personal Key) and URK (User Recovery Key). The UPK is generated using your account details, and never leaves your client. The URK is a public/private key, stored locally in a KeyStore file that's encrypted by Windows. This is transferred to the nCrypted Cloud server, but encrypted again before uploading.

URKs are generated for each file, and contain the unique password required for decrypting that file, which is found in the comment area of the zip file. This allows the file to be recovered using the Recovery Key (along with your user credentials). You can read a more detailed technical overview at **https://bit.ly/ncrypted-encryption**.



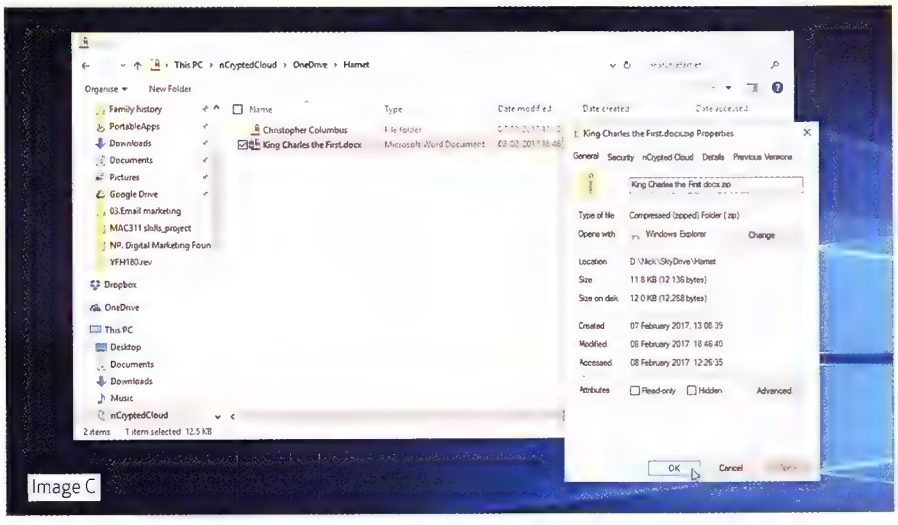


Image C

folder has been protected, complete with a link to the nCrypted Cloud website. People can download the zip file, but they can't access its contents without the unique password assigned to it (see 'How data is encrypted' above).

4 WORK WITH ENCRYPTED FILES

This confirms that the files are now protected by a second layer of encryption, so inaccessible to anyone even if they somehow gain access to your cloud provider account through the web. Look carefully at the file in File Explorer, however, and it appears to be unchanged. Double-click it, and it opens in the usual way. If you right-click an encrypted file and choose 'Properties', however, you'll see it's now identified as a zip file (switch to the nCrypted Cloud tab and the file's actual properties are revealed, including its size) [**Image C**].

What's happening? The nCrypted Cloud app on your PC is invisibly decrypting any files you open, then encrypting them again once they're closed — including any saved changes. There's a slight pause with larger files, but otherwise the process is seamless.

5 LIMITATIONS

One major limitation of nCrypted Cloud is that some applications can't access your encrypted files from their traditional 'Open' dialog boxes. Those that use the latest Windows 'Open/Save' dialog box, which contains the same Navigation pane found in File Explorer, have no problems opening files, but older programs that use a different style of dialog — typically with a 'Places' bar, listing five basic shortcuts — can't access files within protected folders; instead, they simply see the encrypted zip files (if they see anything at all).

To work around this problem, you need to open the file from within File Explorer — right-click and choose 'Open with...' to select your target app, if it isn't already the default for that file. Similarly, when you save files in these applications, they're saved without encryption — to fix this, right-click the file (or its parent folder, if there are a lot of files to process) and choose 'nCrypted Cloud › Re-apply policy' (or 'Make Private', if that option isn't present).

6 MORE ENCRYPTION OPTIONS

The 'Make Private' option can also be applied to individual files within your cloud folder when you right-click them [**Image D**]. Sadly, you can't select multiple files or folders at once to make them private — presumably for safety reasons — so you have to wade through your folders one at a time. Should you later wish to make files or folders publicly available again, right-click them as before, but this time choose 'Remove Privacy', clicking 'Yes' when prompted.

If you move a file from one folder to another within your cloud folder, you get a warning telling you the policy of the file will be changed to your name. This isn't important unless you've set up multiple identities, which is beyond the scope of this tutorial, so ignore it.

If you try to move or copy the file outside of your cloud folder by dragging it to another folder or drive, you end up transferring the encrypted zip file instead. Just drag it back into your cloud folder to make it accessible again. If you want to make an unencrypted copy of your target file or folder, right-click it in File Explorer, and choose 'Copy Unprotected' to transfer it to the clipboard, then simply browse to your target folder, and press 'Ctrl-V' to copy the unprotected file.

7 SET UP TRUSTED SHARING

Like all good cloud providers, nCrypted Cloud makes it possible

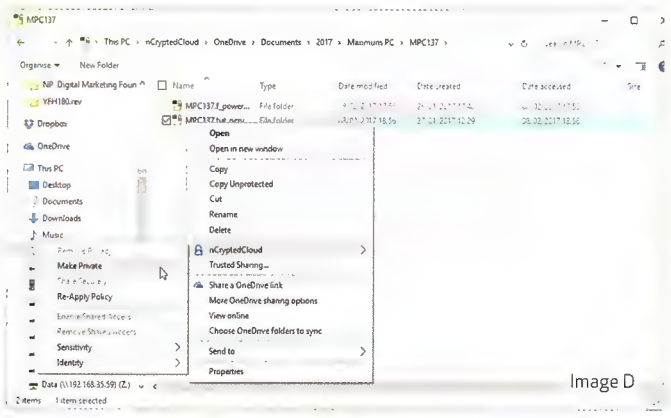


Image D

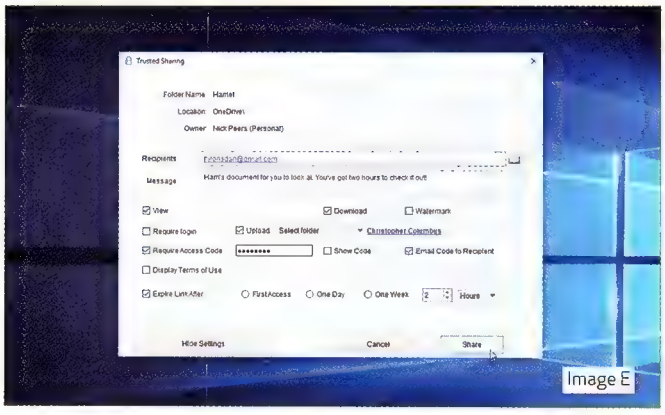


Image E

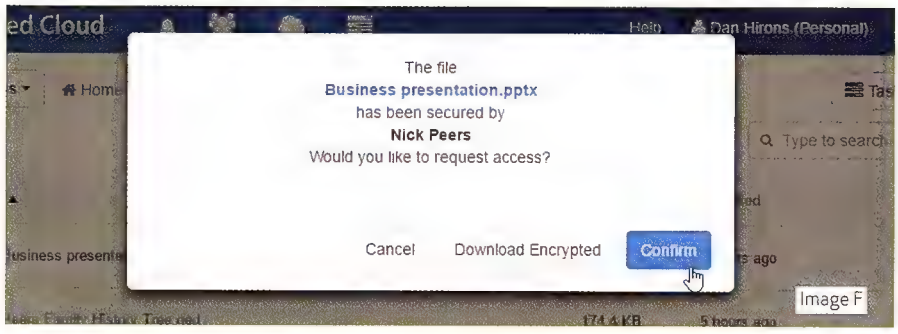


Image F

to share selected data with trusted users. Better still, they don't need to have their own cloud storage account or sign up for nCrypted Cloud. Simply right-click the file or folder you wish to share, and choose 'Trusted Sharing'. A new window appears. Type the email address of each person you want to share the folder or file with into the Recipients box (click the button to its right to use your Outlook address book). You can also add a suitably descriptive message to explain what's happening here, too.

If necessary, click 'Edit Settings' to fine-tune permissions. By default, your audience can only view the file or folder you send them. Select 'Download' to allow them to download an unencrypted copy of the file to their own computer, and select 'Upload' if you'd like them to be able to make changes to some or any of the shared content (you select what after checking the box), and then upload the file back through their browser **[Image E]**.

You'll also see a Watermarked option – select this, and any shared files are watermarked with the recipients' email and IP addresses, discouraging any potential data leaks.

For additional security, select 'Require Access Code' so your recipients need to enter an additional alphanumeric password to gain access to the files. Select 'Email Code to Recipient' to send a separate email containing the access code, or – if you're ultra-cautious – communicate it to your selected recipient separately, perhaps by phone.

You'll see the link is set to expire after one week – once this date passes, it won't work. You can change this so the link only works once, expires after a day, or choose Other to set an expiry time by minute, hour, day or month. Once you're happy, click 'Share'.

8 HOW TRUSTED SHARING WORKS

Your recipient then receives one or two emails (the second containing the access code, if you opted to share it). Clicking 'Access Share' takes them to a web page where – if necessary – they first need to enter the required access code. Once entered, they're shown the selected files or folders in the same Explorer-like interface you use when accessing nCrypted Cloud content through your own web browser.

You're notified by email whenever anyone accesses the file, and if uploading is permitted, you're also alerted when someone either uploads new files or folders to the share, or makes changes and uploads edited copies of existing files to the nCrypted Cloud collaboration page (they can overwrite the original or opt to create a duplicate).

To make changes to your share, log in to your account at **https://login.ncryptedcloud.com**, click the Collaboration Management icon and go to My Shares. Click the Settings button next to the shared folder, where you'll find options for revoking access, extending the expiry date or tweaking the sharing settings.

9 SHARED ACCESS

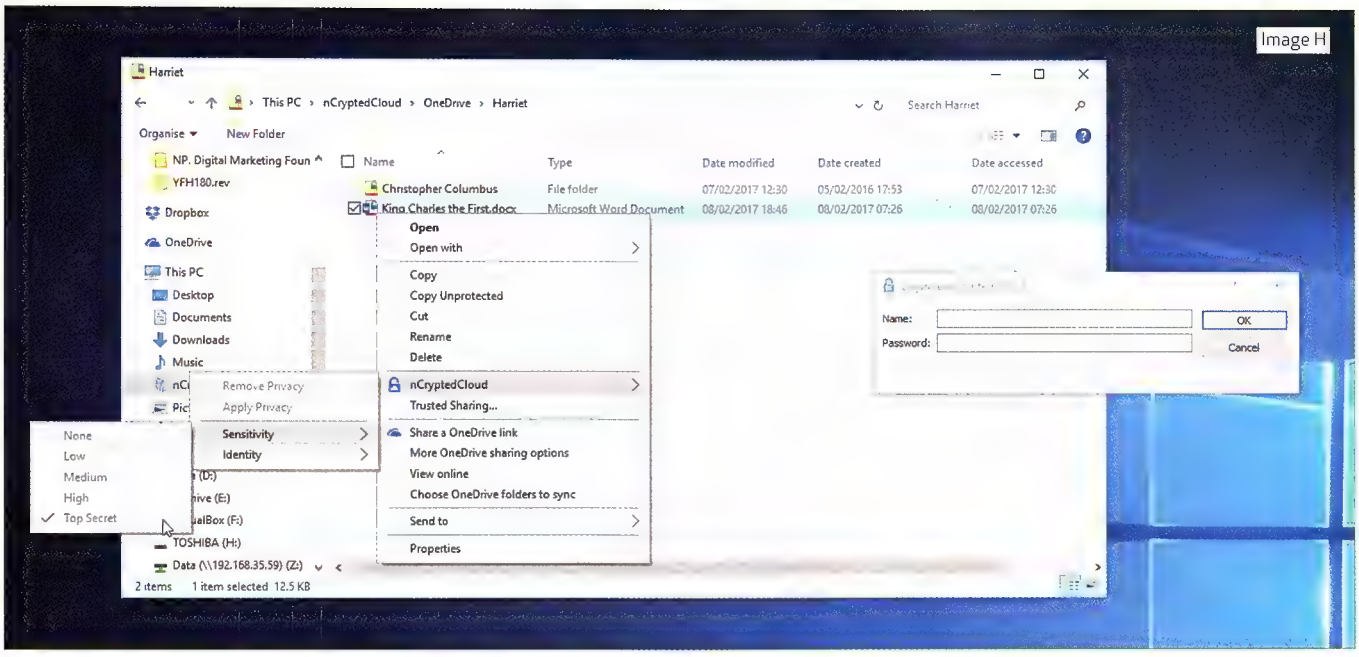
While Trusted Sharing is a good way to quickly share selected files and folders with anyone, if you plan to take collaboration to the next level, you and your confidants need their own Dropbox and nCrypted Cloud accounts (they obviously need to link both accounts together, too – go to 'Preferences > Account' in nCrypted Cloud to do so). Once done, you can share a folder over the same cloud service without having to remove its encryption.

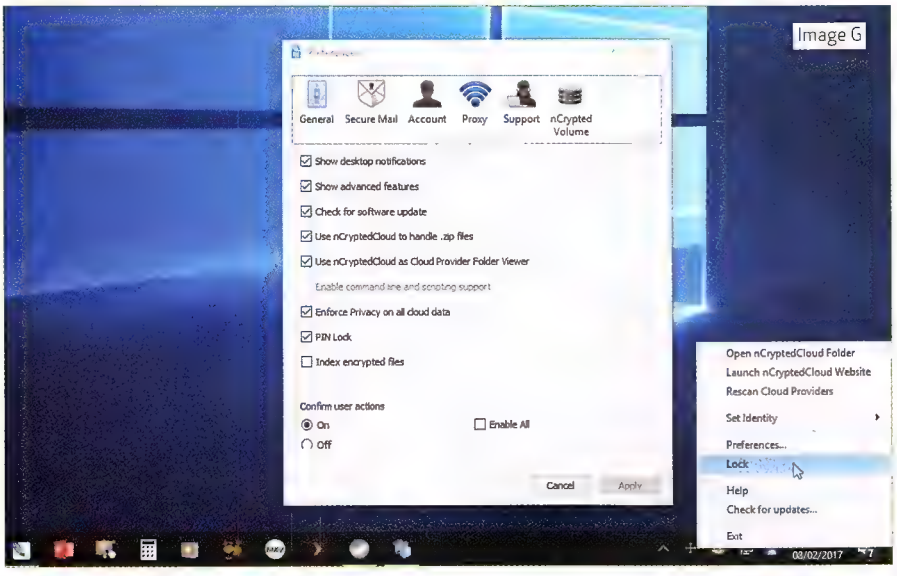
If you'd like anyone you've shared the folder with to have access, right-click the folder in File Explorer and first choose 'Enable Shared Access' to set up open enrolment – this means anyone with an nCrypted Cloud account automatically gains access to the folder when you share it with them through their own nCrypted Cloud account. Don't select this if you want to review requests on a case-by-case basis.

Finally, right-click the folder again and choose the 'Dropbox Share' option. Share the file in the usual way and, after your recipients accept the invitation in Dropbox, they can view the folder's contents normally in the nCrypted Cloud app, or online at the nCrypted Cloud web portal. If you skip open enrolment, when they attempt to open a file, they're prompted to either download the encrypted (and therefore unreadable) file, or ask for access **[Image F]** – you're prompted by email. Revoke access at any time by simply right-clicking the file or folder in File Explorer and choosing 'Remove Shared Access' to remove everyone or 'Shared With...' to view and revoke access on an individual basis.

10 LOCK YOUR FILES

If you've got a PC or device in a shared location, you can lock your encrypted files when you're not at your desk. First log into your account at **https://login.ncryptedcloud.com**, then browse to 'Settings > Personal PIN'. Set a numerical PIN code (the longer, the more secure, obviously), and click 'Update'. Exit and restart nCrypted





Cloud on your PC, then right-click its Taskbar Notification area icon and choose Preferences. You'll now see that 'PIN Lock' is no longer grayed out [**Image G**] – select this, enter your PIN code, and click 'Apply'.

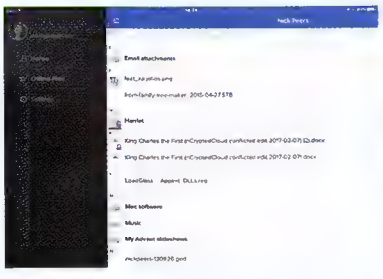
Right-click the nCrypted Cloud Taskbar Notification area icon again, and you'll see a new 'Lock' option. Select this, and your protected storage folders – encrypted or otherwise – are all off-limits. Right-click the icon again and choose 'Unlock', followed by your PIN, to make them accessible again. When 'PIN Lock' is enabled, you are also prompted to enter your PIN whenever you start your PC.

11 PROTECT SENSITIVE FILES

Last, but not least, want to apply additional protection to individual files or folders? Right-click the nCrypted Cloud Taskbar Notification area icon and choose Preferences. Check the 'Show advanced features' box on the General tab, then click 'Apply'. When you next right-click an item and open the nCrypted Cloud submenu, you'll see a new 'Sensitivity menu, offering five choices. Select one, and the item is colour-coded accordingly, from green (Low) through yellow (Medium), orange (High) and finally red (Top Secret). Select 'none' to remove any sensitivity setting.

This is fine, but how does it better protect your files? Simple: If you mark an item Top Secret, you're prompted to enter your nCrypted Cloud account credentials each time you access it through the app [**Image H**], providing another welcome layer of protection.

Access from other devices



It's unlikely that you're happy being able to access your data from just your PC. One way to temporarily access your files from any device is through a secure web browser — go to **https://login.ncryptedcloud.com** and log in. You can browse your entire cloud storage and access your encrypted files and folders without having to worry about them. Click a file to view it in your browser, or click the '...' next to it for more options, including downloading the file in its original, non-protected form. Better still, you can download and install the nCrypted Cloud app on Windows and Mac, enabling you to access your data seamlessly on other desktops and laptops. You can also install the nCrypted Cloud app on your iOS or Android device — search the relevant app store for 'ncrypted' (select the newer Pro version if it's available) — and use that to access your data on the move.

Worried about unauthorised access? Every time you connect a new device, you receive an email. You can manage connected devices from your account page at **https://login.ncryptedcloud.com** — go to 'Settings > Devices' to review currently connected apps. Click 'Unlink' next to any to immediately revoke its access.

Master Mission Control on Mac

Work more efficiently with multiple desktops in macOS Sierra.

Mission Control has been a feature of the OS X operating system (now macOS) since 2011, when it appeared as part of the release of OS X 10.7 Lion, but its roots go back to Exposé, which made its debut back in 2003 with OS X 10.3 Panther. As the name implies, Mission Control is envisaged as the control centre from which you run your Mac. In reality, you could use your Mac for years without ever activating it, but it's very handy when you need to find that one crucial app you've lost behind a dozen open folders, or you simply need to get a handle on which apps you currently have running.

Apple refined Mission Control with the release of OS X El Capitan in 2015 and we're pleased to say that nothing has changed: the desktop background in Mission Control is not blurred like it was in previous versions, and thumbnails of virtual desktops don't appear until your cursor moves over them.

Here, we're going to show you how to use the features of Mission Control in macOS Sierra, how to manage your apps and different desktop spaces, and how you can customise Mission Control in the Settings app. So let's take control of your Mac and get started!

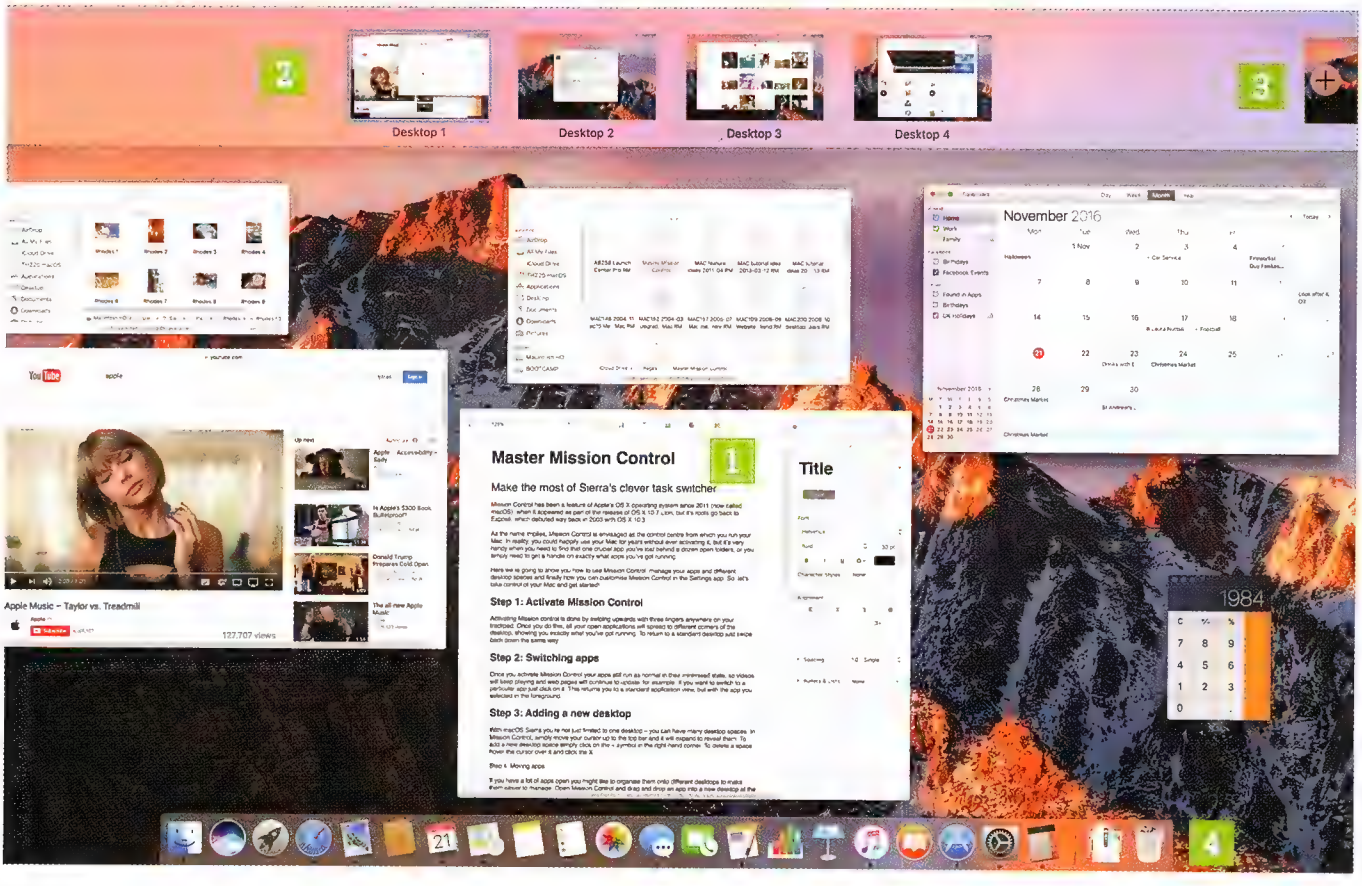
Stay in control

1 RUNNING APPS
When you enter Mission Control, all the apps currently running on your system minimise to their own, well-organised areas of the screen, so you can see what's going on.

2 TOP BAR
Move the cursor to the top of the screen in Mission Control to reveal the top bar, where you can access all your desktop spaces.

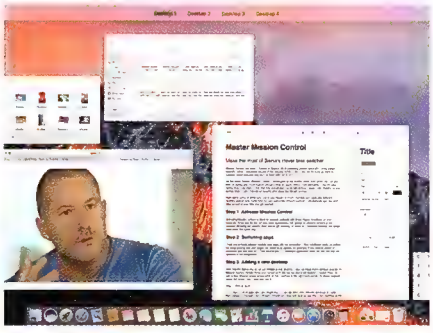
3 DESKTOP SPACES
The different desktop spaces you've created are a bit like multiple monitors you can swap between, and can be accessed from the top bar. Click the '+' icon to open a new space.

4 THE DOCK
The Dock stays visible throughout Mission Control, which means you can still launch your favourite apps at any time.



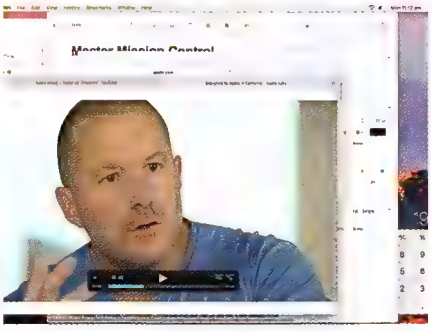
How to

Navigate Mission Control in Sierra



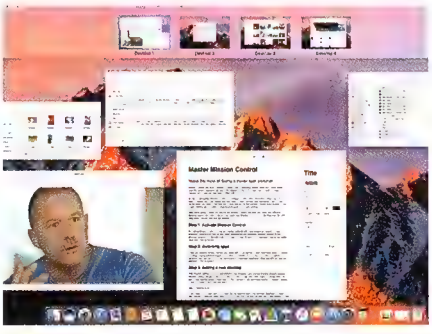
1 ACTIVATE MISSION CONTROL

Activating Mission Control is done by swiping upwards with three fingers anywhere on your trackpad. Once you do this, all your open applications will spread to different corners of the desktop, showing you exactly what you have running. To return to a standard desktop, just swipe back down the same way.



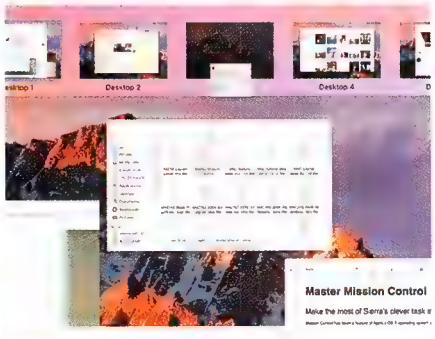
2 SWITCHING APPS

Once you activate Mission Control, your apps still run as normal in their minimised state, so videos will keep playing and web pages will continue to update. If you want to switch to a particular app, just click on it. This returns you to a standard application view, but with the app you selected in the foreground.



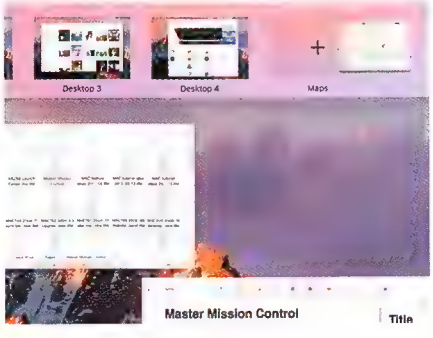
3 ADDING A NEW DESKTOP

With macOS, you're not just limited to one desktop — you can have many desktop spaces. In Mission Control, simply move your cursor up to the top bar and it will expand to reveal them. To add a new desktop space, simply click on the '+' in the right-hand corner. To delete a space, hover the cursor over it and click the 'X'.



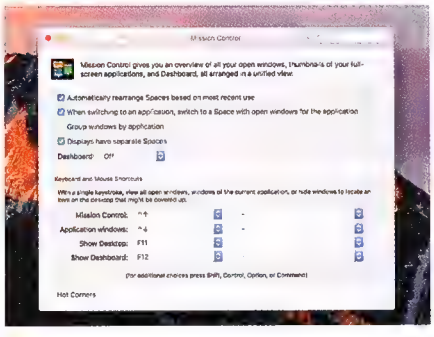
4 MOVING APPS

If you have a lot of apps open, you might like to organise them onto different desktops to make them easier to manage. Open Mission Control and drag and drop an app into a new desktop at the top of the screen. Drop it onto the plus symbol at the top right and you'll create a new desktop to drop the app into.



5 ADDING APP SPACES

You're not limited to putting apps into desktop spaces — you can also drag them to the top bar and let them float in a space of their own. These apps don't belong to a desktop: they can be accessed via Mission Control or the Option-Tab app switcher. You can drop another app on them to enter a Split View mode.

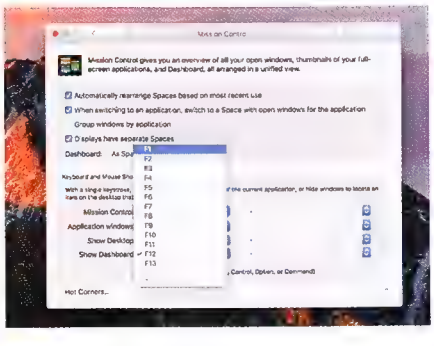


6 MISSION CONTROL SETTINGS

You can customise Mission Control in System Preferences. Open up System Preferences from the Dock and choose Mission Control in the top line of icons. Here, you can choose a different way of launching Mission Control from the pop-up menu. Try it!

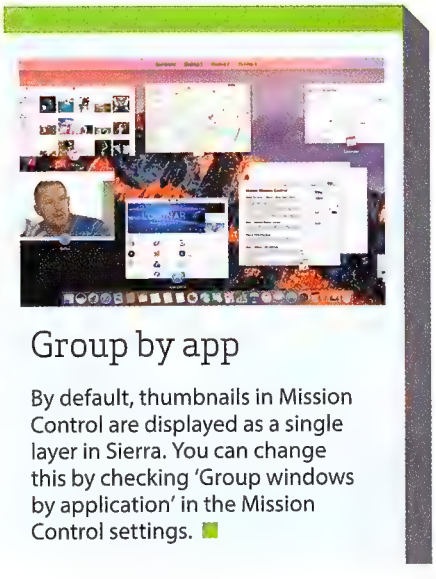
7 DASHBOARD SETTINGS

Dashboard is turned off by default in macOS Sierra. In the Mission Control settings, you can turn it back on and choose whether to overlay Dashboard onto your desktop or give it its own space. Choose an option and hit F12 to launch.



8 CHANGE SHORTCUTS

You can change the keyboard, trackpad or mouse shortcuts to Mission Control, Dashboard and Show Desktop in Mission Control settings but if you press the Shift, Control, Option or Command keys while looking through the list you'll find, you can add these keys to the choices.



Group by app

By default, thumbnails in Mission Control are displayed as a single layer in Sierra. You can change this by checking 'Group windows by application' in the Mission Control settings. ■

Reclaim wasted iCloud space

Be frugal and get back your online storage capacity with Alan Stonebridge.

It's tempting to leave certain settings on your iPhone or iPad on their defaults, not least iCloud Backup – how many times has the importance of backing up been hammered into your brain, after all. That may seem like the safest strategy, but ask yourself whether it's costing you more money than necessary.

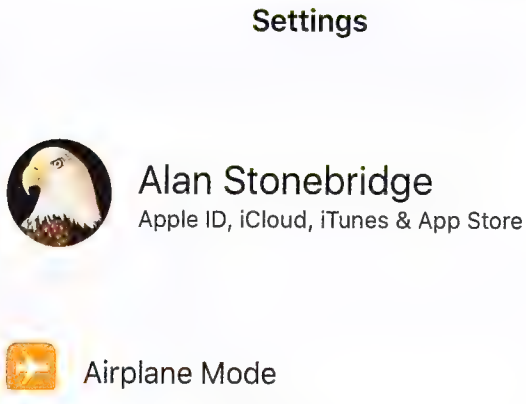
While writing this tutorial, we were shocked to discover that iCloud Backup was putting 941MB of data from Tweetbot and 459MB from Amazon Music online. Neither of those apps stores anything we can't easily obtain again. So if you're trying to stay within the 5GB Apple provides for free with all iCloud accounts, we suggest checking the space your backups are taking up, and whether that's close to costing money that you don't really need to spend.

However, if you're already paying for more space in your iCloud account, and an ample amount remains free, you may not care to follow our advice here, as it isn't going to change anything for the better for you, at least for now.

The following walkthrough is written with iOS 10.3 in mind, which was released just as we went to press. That update relocates some of the settings you'll need to access, but the same principles apply in previous versions – instead of tapping the new consolidated row for your Apple ID, iCloud, iTunes and App Store accounts at the top of Settings, scroll down and look in the discrete iCloud submenu instead.

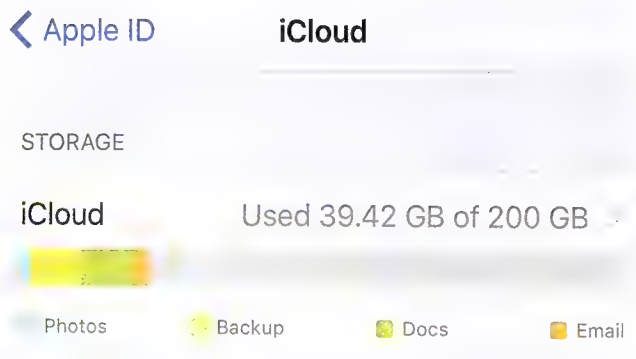
How to

Reclaim wasted iCloud storage



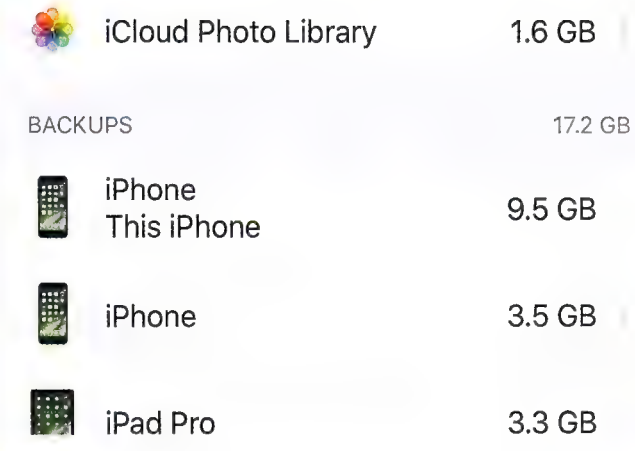
5 LOCATE ICLOUD SETTINGS

In the recent iOS 10.3 software update, Apple consolidated settings that relate to your Apple ID, iCloud and the iTunes and App Stores in one place, which is conveniently at the top of Settings. Start by tapping that row.



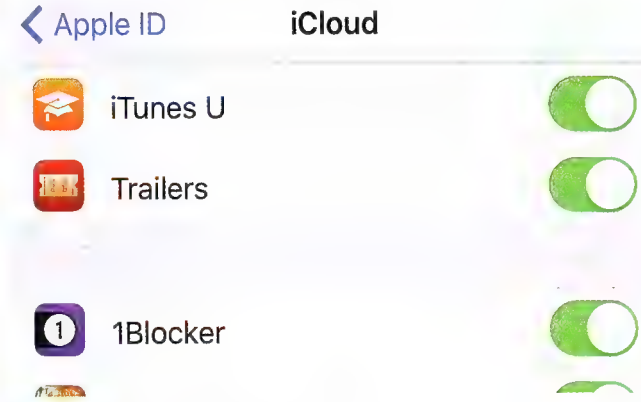
6 ICLOUD STORAGE USAGE

Tap iCloud near the top of the next page. You'll see a colour-coded breakdown of what's using your iCloud storage — not just iCloud Drive, but email and backups, too. Tap that, and then tap 'Manage Storage'.

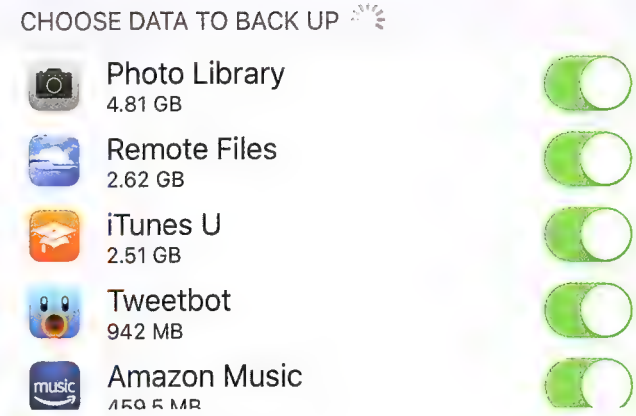


3 FINER DETAILS
The next page breaks things down more precisely. Ignore the 'Documents & Data' section lower down, despite it listing how much iCloud storage each of your apps is using. Instead, under Backups, tap the device you're using.

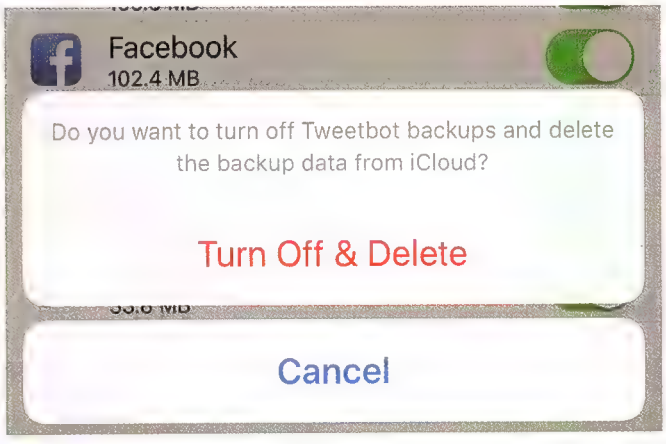
5 IS IT NECESSARY?
Several of our apps' backups were using a significant amount of the storage iCloud gives you for free. Consider turning off backups for apps that contain media that's free to redownload or for which there's no benefit.



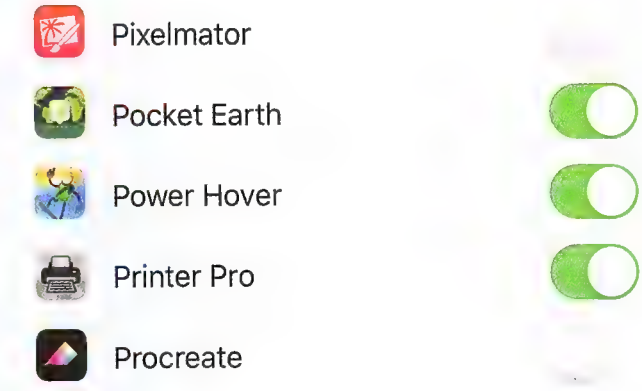
7 WHAT SAVES TO ICLOUD
As well as disabling backups for apps, consider whether apps should save content to iCloud Drive at all, or if you're content to use File Sharing (see **apple.co/2nObcTV**) to move files to and from your Mac manually.



4 IDENTIFY SPACE HOGS
Under the heading 'Choose Data to Back Up', tap 'Show All Apps', and then work your way down the list, noting any apps whose usage you consider excessive or unnecessary. You may be surprised by what's backed up online.



6 FREE UP THE SPACE
When you switch off an app's backups, you're asked to confirm; doing so deletes the backup data from iCloud immediately, freeing up space for what really matters, such as data that actually warrants being backed up.



8 LIMIT SELECT APPS
At the top of iCloud's settings, scroll past 'Apps Using iCloud' to third-party apps. Check online whether those that use lots of space support an easy transfer method (File Sharing or AirDrop); switch off those that do.

Spy tech: Hide private data within other files on Linux

Hide your private data in ordinary files with this most excellent steganography program and the curiously named Nate Drake.

Back in 440BC, the tyrant Histiaeus, knowing his messages were being intercepted, shaved the head of his most trusted slave (an oxymoron if there ever was one) and tattooed a message to his vassal Aristagoras. Time was clearly abundant as the slave was allowed to wait until his hair regrew, then duly sent off with a harmless-looking letter in hand. He asked Aristagoras to shave his head and read the real message on arrival, which instructed the vassal to revolt against the Persians.

If we overlook momentarily the fact that it would have been far easier to give the slave the secret message to deliver orally, this is the first recorded use of steganography, where a secret message is hidden inside an ordinary looking one.

In our modern wired world, where we don't have time to sit and watch the bristles regrow, steganography (often shortened to 'stego') is accomplished through various computer programs. While there are many stego programs available, all work on roughly the same principle. First, a secret file is created, such as a text document with a message. This is then placed inside a harmless-looking container file such as a picture of your pet kitten.

Certain files such as images contain seemingly random digital 'noise' caused by outside factors such as a camera sensor or through some compression technique. Stego tools exploit this noise by hiding the images inside it. It's extremely difficult through analysis of the data alone to tell the difference between a file with garden variety 'noise' and a stego file containing hidden data.

SNEAKY STEGANALYSIS

As promising as stego looks on paper, in the past, it has been something of a digital arms race, with tools being developed to hide images just as fast as other programs are created to detect the use of steganography in files.

There was a brief flurry of worry about this in 2001 when various news sites such as USA Today reported that terrorists were communicating through images posted online in sports chat rooms, adult websites and bulletin boards.

Researchers have devoted months of tireless study to this subject. In brief, it's extremely difficult to prove a negative – i.e. that any given file categorically does not contain some form of secret message.

This, of course, works both ways. With the right tools and some common sense, you can use steganography to protect your darkest secrets while seemingly sharing harmless media files around the internet.

You may wonder why you would choose this over using regular encryption programs to protect your data. The reason is that, each time you send a password-protected file or email to your contact, although it may not be possible to tell what you're sending, anyone who intercepts your message will know you're hiding something and investigate further.

During the Cold War, spies used to drop off and pick up packages at designated 'dead drops' which they'd agree with a contact. Any discrete location was suitable and there was

Home
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Tech Investor
Product reviews
More Tech
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Talk Today
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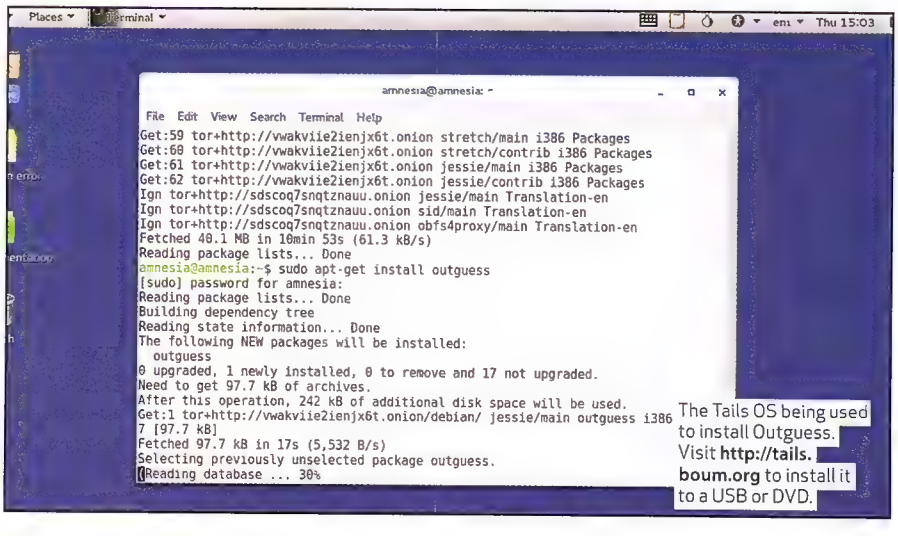
02/05/2001 - Updated 05:17 PM ET
Terror groups hide behind Web en
By Jack Kelley, USA TODAY
WASHINGTON — Hidden in the X-rated pictures on several pornographic Web sites and the posted comments on sports chat rooms may lie the encrypted blueprints of the next terrorist attack against the United States or its allies. It sounds farfetched, but U.S. officials and experts say it's the latest method of communication being used by Osama bin Laden and his associates to outfox law enforcement. Bin Laden, indicted in the bombing in 1998 of two U.S. embassies in East Africa, and others are hiding maps and photographs of terrorist targets and posting instructions for terrorist activities on sports chat rooms, pornographic bulletin boards and other Web sites, U.S. and foreign officials say.
AP
U.S. officials say Osama bin Laden is posting instructions for terrorist activities on sports chat rooms,

The USA Today article claiming Bin Laden used stego. Niels Provos, creator of Outguess, searched thousands of images online and found no evidence of this.

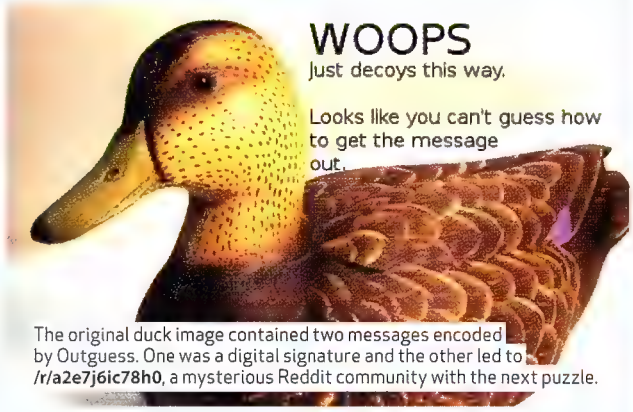

Places
Terminal
Thu 15:03
amnesia@amnesia: ~
File Edit View Search Terminal Help
Get:59 tor+http://vwakviie2ienjx6t.onion stretch/main i386 Packages
Get:60 tor+http://vwakviie2ienjx6t.onion stretch/contrib i386 Packages
Get:61 tor+http://vwakviie2ienjx6t.onion jessie/main i386 Packages
Get:62 tor+http://vwakviie2ienjx6t.onion jessie/contrib i386 Packages
Ign tor+http://sdscoq7snqtznauu.onion jessie/main Translation-en
Ign tor+http://sdscoq7snqtznauu.onion sid/main Translation-en
Ign tor+http://sdscoq7snqtznauu.onion obfs4proxy/main Translation-en
Fetched 40.1 MB in 10min 53s (61.3 kB/s)
Reading package lists... Done
amnesia@amnesia:~$ sudo apt-get install outguess
[sudo] password for amnesia:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
outguess
0 upgraded, 1 newly installed, 0 to remove and 17 not upgraded.
Need to get 97.7 kB of archives.
After this operation, 242 kB of additional disk space will be used.
Get:1 tor+http://vwakviie2ienjx6t.onion/debian/ jessie/main outguess i386 7 [97.7 kB]
Fetched 97.7 kB in 17s (5,532 B/s)
Selecting previously unselected package outguess.
(Reading database ... 30%
The Tails OS being used to install Outguess. Visit **http://tails.boum.org** to install it to a USB or DVD.

Duck and uncover

Around five years ago, a mysterious organisation named Cicada 3301 began posting a series of increasingly difficult puzzles online in a bid to recruit "highly intelligent individuals". The first puzzle in 2012 was an image with a small text file at the end. This was encoded with a simple Caesar cipher whereby each letter of the alphabet is shifted a certain number of letters (in this case four).

This, in turn, led to an image of a wooden duck with the message "Woops! Just decoys this way. Looks like you can't guess how to get the message out." Savvy crypto-nerds across the world combined their collective genius and realised that the words 'guess' and 'out' meant that there was a message hidden in the image using Outguess. The solution to this puzzle led to another on a Reddit page based on Mayan numerals. As you need to solve each puzzle to continue onto the next, only a handful of people claim to have completed Cicada 3301's challenges and their claims are hard to verify after solutions are posted publicly.

We know virtually nothing about who Cicada 3301 are or why they are trying to recruit gifted people. Challenges in subsequent years became increasingly complex, involving QR codes on lamposts from Poland to Hawaii, as well as custom websites and recorded telephone messages. The puzzles stopped around a year ago but those interested in seeing past challenges can visit **https://cicada3301.org**.



The original duck image contained two messages encoded by Outguess. One was a digital signature and the other led to **/r/a2e7j6ic78h0**, a mysterious Reddit community with the next puzzle.

no requirement for the spy and their handler to visit the dead drop at the same time.

Steganography can operate as a form of digital dead drop. If, for instance, you hide your files inside an image and then upload that image to a website, you don't even need to be online at the same time as your contact, nor do you even need to know one another.

TAILS OF OUTGUESS

Niels Provos' excellent command line utility Outguess is the chosen stego tool for this tutorial. This is firstly because it is available to install from Ubuntu/Debian repositories and also because it's very simple to use.

Although the tool hasn't been updated for a while, it is futureproofed by allowing you to hide two messages inside a container file with separate passwords. This works in a similar way to the plausible deniability feature in encryption programs such as VeraCrypt. If ever a way is found to detect the use of stego in your files, you can use the decoy password to reveal some pre-prepared fake information.

One way that your use of stego can be detected is by analysing your hard drive for the presence of Outguess or checking your internet history to see if you've downloaded it. For this reason, we recommend using the TAILS operating system for this project.

TAILS loads entirely into your RAM memory so all traces of activity are lost a few minutes after you shut down the machine, including the files you used and the Outguess program itself.

Another advantage of TAILS is that it routes all connections through the Tor network. This makes it virtually impossible for anyone monitoring your connection to tell that you've downloaded TAILS, nor where you have uploaded your container file with the hidden message.

BEGIN YOUR BOGUS JOURNEY

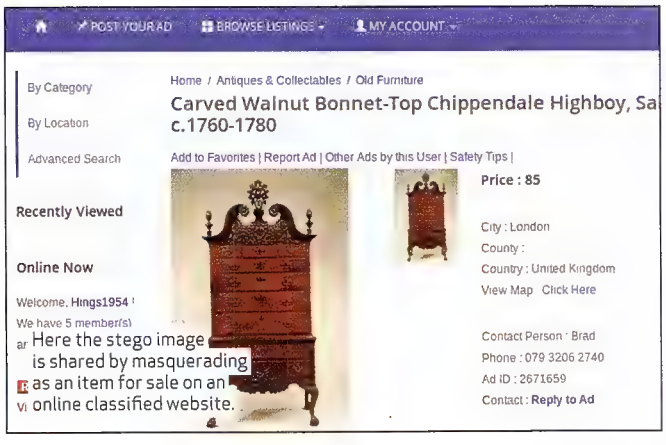
For the purposes of this project, imagine that you have been able to purchase the coveted *Bill and Ted's Most Excellent Collection* on DVD, which comes complete with both films and the extras disc with the instruction video on how to play air guitar professionally.

You are rightly concerned about this prized possession being stolen so decide to bury the DVD box set, so you can dig it up and sell it 20 years from now.

After hiding the box set, you decide you want to share the location with a trusted relative in case you're unable to retrieve it. You meet with them privately to agree on a password to use and that you'll hide the location inside the image of an antique Chippendale cabinet.

As you both live in a police state where the government has a hankering for '90s classics, you also agree on a decoy password that either of you can enter under duress to reveal a false location.

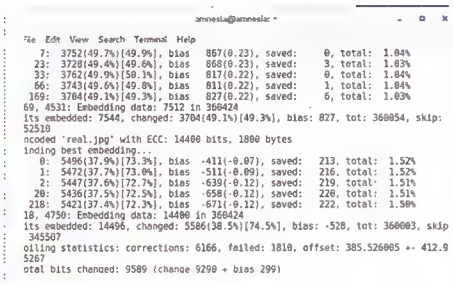
You both also agree to use a Live DVD to install Outguess and encode/decode files to make sure there's no trace of the tool on your respective machines.

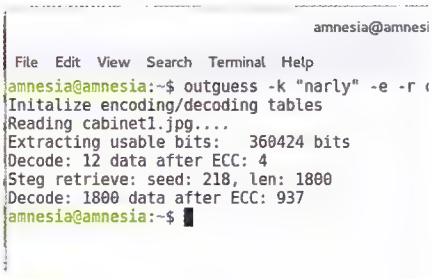


Here the stego image is shared by masquerading as an item for sale on an online classified website.

Here, the two files 'real.jpg' and 'fake.jpg' have been embedded in the image 'cabinet.jpg' to create a new file 'cabinet1.jpg'.

Steganography in three simple steps


amnesia@amnesiac: ~
File Edit View Search Terminal Help
7: 3752(49.7%)[49.9%], bias 867(0.23), saved: 0, total: 1.04%
23: 3728(49.4%)[49.6%], bias 868(0.23), saved: 3, total: 1.03%
33: 3762(49.9%)[50.1%], bias 817(0.22), saved: 0, total: 1.04%
66: 3743(49.6%)[49.8%], bias 811(0.22), saved: 1, total: 1.04%
169: 3784(49.1%)[49.3%], bias 827(0.22), saved: 6, total: 1.03%
69, 4531: Embedding data: 7512 in 360424
its embedded: 7544, changed: 3704(49.1%)[49.3%], bias: 827, tot: 360054, skip: 52510
ncoded 'real.jpg' with ECC: 14400 bits, 1800 bytes
inding best embedding...
0: 5496(37.9%)[73.3%], bias -411(-0.07), saved: 213, total: 1.52%
1: 5472(37.7%)[73.0%], bias -511(-0.09), saved: 216, total: 1.52%
2: 5447(37.6%)[72.7%], bias -639(-0.12), saved: 219, total: 1.51%
20: 5436(37.5%)[72.5%], bias -658(-0.12), saved: 220, total: 1.51%
218: 5421(37.4%)[72.3%], bias -671(-0.12), saved: 222, total: 1.50%
18, 4750: Embedding data: 14400 in 360424
its embedded: 14496, changed: 5586(38.5%)[74.5%], bias: -528, tot: 360003, skip: 345507
oiling statistics: corrections: 6166, failed: 1810, offset: 385.526005 +- 412.95267
otal bits changed: 9589 (change 9290 + bias 299)


amnesia@amnesi
File Edit View Search Terminal Help
amnesia@amnesia:~$ outguess -k "narly" -e -r
Initalize encoding/decoding tables
Reading cabinet1.jpg....
Extracting usable bits: 360424 bits
Decode: 12 data after ECC: 4
Steg retrieve: seed: 218, len: 1800
Decode: 1800 data after ECC: 937
amnesia@amnesia:~$

1 INSTALL OUTGUESS

Boot up your operating system of choice (ideally TAILS in this instance) and open the Terminal. Run `sudo apt-get update` then run `sudo apt-get install outguess`. While the update and install are running, take the time to move your outer container file, as well as the real and fake files, into your home folder. Feel free to name these files something as obvious as "real" and "fake", as Outguess doesn't store the original filenames.

2 ENCODE FILES

Assume the container file is called 'cabinet.jpg' and the real and fake files are called 'real.jpg' and 'fake.jpg', encoded with the passwords "narly" and "bogus", respectively. The output file is called 'cabinet1.jpg'. In this case, the command to hide the files would be:

```
outguess -k "bogus" -d fake.png -E -K "narly" -D real.png cabinet.jpg cabinet1.jpg
```

Feel free to change any of these values when creating your own stegos.

3 DECODE FILES

Once your files have been uploaded, your contact should repeat Step 1, then download the steg file. If they're acting under duress, they can run this command with the decoy password to reveal the fake file decoded.jpg:

```
outguess -k "bogus" -r cabinet1.jpg decoded.jpg
```

Otherwise, they can reveal the real file thus:

```
outguess -k "narly" -e -r cabinet1.jpg decoded.jpg
```

You decide to use a QR code to store the GPS coordinates of both the real location of the DVD box set and a fake location, as these are easy to scan into a phone and open in apps such as Google Maps.

Once the stego file has been prepared, your friend can retrieve it at any time to work out where the *Bill and Ted* film offering is hidden.

STEGO THE DUMP

Although using Outguess from a bootable version of Linux such as TAILS will remove all traces of tools and any files you worked on, it won't delete the original secret and container files. Ideally, you should create these while in the 'Live' system, but if not use the `shred` command on relevant data once you're finished.

One important point: whether you use an image, sound file or video, remember to record it yourself. If a copy of the original 'un-stegged' file is available online, it can be compared to yours and the use of steganography can be detected. If you decide to upload a series of photos of the same item such as an antique cabinet, remember that these should all be roughly the same size.

When agreeing the password with your contacts, work out a system whereby they'll know where to find the container files. For instance, you might agree to post a classified advert at a set time each week or you might list a certain phone number alongside each image containing hidden files.

Many sites compress or otherwise alter media files after upload. Try to find one that allows you to upload files unaltered or post a link where the original can be downloaded.

If you live in a jurisdiction with compulsory key disclosure laws, such as the UK, then technically, you must surrender all keys in your possession when ordered. This includes both the bogus password and the real one. Take time to check the legality of using stego and withholding the real password where you live.

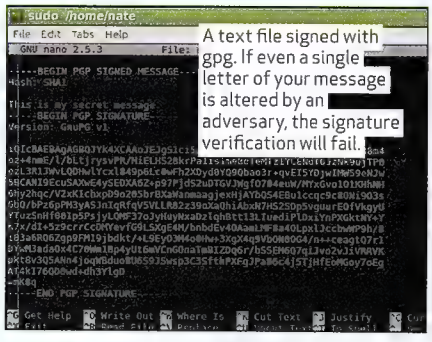
Message authentication

The fact that you don't need to meet with your contacts to send secret stego messages is both a strength and weakness. If an adversary were to discover your steg file, they could replace it with one of their own, containing false information in a bid to trap you or your contacts.

For this reason, consider using the command line utility `gpg` to digitally sign any messages you send. This utility is traditionally used for encrypting data — files are encoded with a 'public' key which you make available to everyone and decoded by a separate 'private' key which never leaves your computer.

The process, however, can work in reverse, whereby you encode a file with your private key. This offers no security in terms of reading data, as anyone in possession of your public key can read the file, but it does allow them to be sure it was you who sent a message.

Full instructions for using gpg can be found at **www.gnupg.org/documentation/manpage.html**. Any attempt to alter the contents of the file will result in a 'bad' signature.



A text file signed with gpg. If even a single letter of your message is altered by an adversary, the signature verification will fail.

Whenever you tell gpg to sign a file, it will create a new file with the extension '.asc', which you can then hide inside a container file using Outguess. This works for all kinds of files. When your contact receives the signed .asc file, ask them to run the command `gpg --output filename.jpg --decrypt filename.jpg.asc` where filename.jpg.asc is the extracted file.

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Put together a patchwork PC

Your older hardware needn't be consigned to the scrapheap — Alan Dexter says put it to use in a patchwork PC.

THE CONCEPT

We are asked to piece together machines all the time here on *APC*. These one-off projects are generally short-lived, and are designed to solve a particular problem or help elsewhere: a quick boost to a rendering farm, say, or to see whether a new graphics card or CPU really improves performance in a particular application. We also get more specific requests, such as a recent one to build a system for games coding.

The caveat on this one was for a machine that they would get to keep – something we don't normally do because the components generally need to be returned to our hardware hoard for future builds. However, we were feeling benevolent, so set out to put some of the older gear to good use.

When it comes to coding, there aren't many specialist requirements above and beyond what you would want from a modern machine. A little more memory than the bare minimum helps, as does a speedy multi-core processor for compiling, and fast drives can make a difference when throwing around high-resolution assets. But in general, any PC can turn its hand to the task. Still, it helps to know what the machine will be used for when picking components.

BEGGARS CAN BE CHOOSERS

This build was a departure from the norm, in that it wasn't a case of starting with a shopping list, then tracking down an ideal collection of hardware from which to build a glorious system. Instead, it was about looking at what was in the storeroom, what wasn't likely to be recalled, and what would work together to form a machine that was fit for purpose. So we trawled through our spreadsheets and dusty cupboards for parts that were viable, if not exactly cutting-edge.

Our first port of call was the AMD FX-8370, which is a reasonable enough processor, if not quite competitive with Intel's offerings. It's an 'eight-core' chip that relishes multi-threaded environments, though it struggles at less parallel work. The price doesn't make a lot of sense either, which is why it's been languishing in our chip drawer, waiting for a moment to shine. We've slotted this into the MSI 970 Gaming, which is a thrill-free but competent board.

For graphics, the ASUS Strix 960 2GB is beginning to show its age, but it handles older games without a problem. The rest of the spec is fairly straightforward, with the exception of storag e —where we'd normally use a spinning drive alongside a speedy boot SSD, we've employed another SSD for that task. This will help keep access speeds up, while providing plenty of space at the same time. It's a pricey solution, but it makes sense to focus the potential budget where it counts.

PARTS LIST

PART		STREET PRICE
CASE	BITFENIX SHADOW	$75
MOTHERBOARD	MSI 970 GAMING	$145
CPU	AMD FX-8370	$290
MEMORY	CORSAIR VENGEANCE PRO 16GB (2 X 8GB) @ 1,866MT/S	$159
GPU	ASUS STRIX 960 2GB	$290
PSU	EVGA 600B	$89
STORAGE 1	HYPERX SAVAGE 240GB	$159
STORAGE 2	OCZ TRION 100 960GB	$480
COOLING	BE QUIET! SHADOW ROCK SLIM	$69
ACCESSORIES	2 X BITFENIX SPECTRE XTREME	$38
TOTAL		$1,794

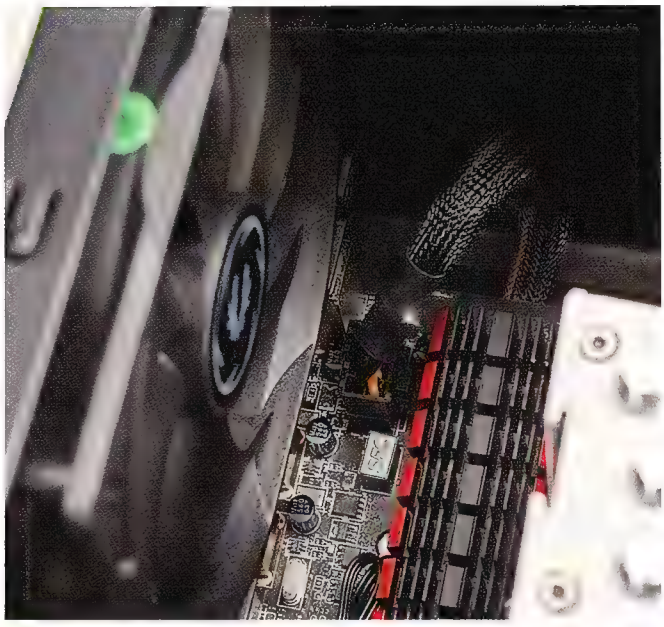
"When it comes to coding, there aren't many specialist requirements above and beyond what you would want from a modern machine."

1 COOL AND QUIET

We admit to being obsessed with cooling, and adding more fans to a case is pretty much the first thing we do with any build. Easing more fans into the BitFenix Shadow was straightforward, as there's room for a pair of 120mm fans behind the front panel. We reached for a couple of the Spectre Xtremes, and screwed them into place after popping off the panel. We were squeezed for PWM fan headers on the MSI 970 Gaming, but didn't want the fans running at full speed all the time, as that would be unnecessary. This is why we attached the fans to the motherboard through a low-noise adapter (LNA), which reduces their running speed, so helps keep noise levels down, and they're nice and cheap.

2 FLOATING STORAGE

The BitFenix Shadow case isn't exactly cutting-edge, but it's not a relic either, which is why we were surprised to discover that there's no easy way to mount SSDs in its monolithic form. There are plenty of drive bays, but the holes for the 3.5-inch bays don't line up with the mounting holes on our SSDs, and the tool-free brackets on the 5.25-inch bays don't fit either. Our solution was to screw the drives into place instead. Unfortunately, this was only possible in the 5.25-inch drive bays, but there's the obvious problem that we couldn't secure the drives in place from both sides, as we couldn't find a mounting bracket. We're not too concerned about the drives only being screwed in on one side, though, because SSDs are light, and won't move under their own weight.

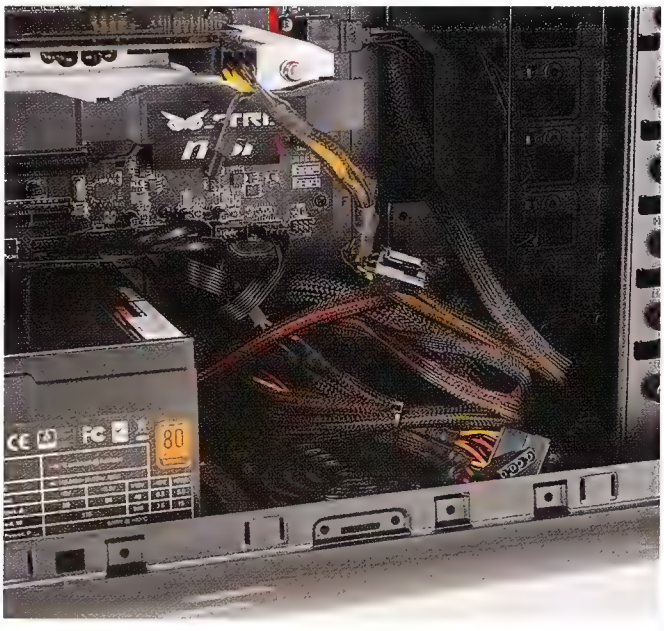


3 OUT OF SIGHT

Keeping your cabling out of the way is a good idea in any build, because it not only keeps the build looking tidy, but it also helps with airflow. Getting the ATX power cables to play ball can often be a pain, though, so you need to plan ahead with regard to how you're going to achieve this. Here we routed the EPS12V cable behind the motherboard, before actually installing the motherboard, so that it was completely out of the way. The main ATX power cable was a little easier to route, thanks to the section behind the drive bays that is designed specifically to help on this front.

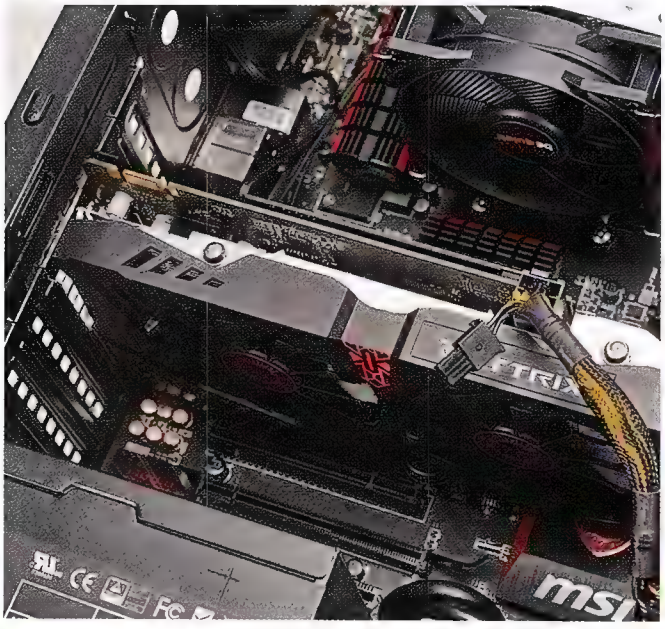
4 FUN WITH BRACKETS

We're so used to installing all-in-one water coolers in our builds that it was something of a shock going back to a straight air cooler. It worked well in practice, though — once we'd actually got it installed. We did need to install a holding bracket on the motherboard before we could use it, which we only realised after screwing the motherboard in place — learn from our mistake, and install the bracket first. Once done, however, the cooler clips into place relatively easily, even if space is a little tight. Installing the cooler before dropping the motherboard into place would have been a wiser move.



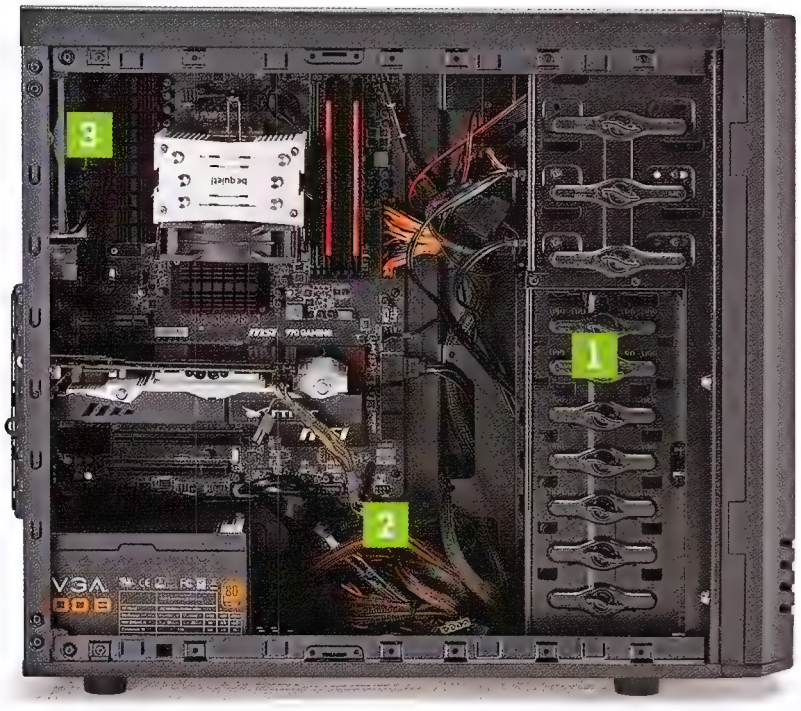
5 THE POWER OF CABLE TIES

The trick with non-modular power supplies is knowing what to do with unused cables — hide them away, truss them up into a central column, or construct a coil out of them. Here, we went for the final option, as there wasn't room to hide them behind the motherboard tray, and a central column wasn't needed. While a little unsightly, tying up the unused connectors with cable ties means they're kept out of the way in terms of airflow, but are available if you add additional hardware. Don't overdo the cable ties, though, as freeing a cable if you need it shouldn't be a chore.



6 GRAPHICS ON A BUDGET

In a perfect world, we'd kit out this machine with a card befitting premium games development: Something along the lines of a GeForce GTX 1080 or even a Titan X would be lovely. However, we can't afford to give such things away as though they're candy, so it was a case of installing what we had spare. The ASUS Strix 960 is a solid card that can handle most games at 1080p with the settings dialed back a little. It's fair to say that upgrading this would offer up the biggest boost to frame rates, though, and there's plenty of room to support such a purchase. The EVGA 600B power supply supports dual eight-pin connectors as well, so no worries on that front.



1 These toolless drive bays are fine for traditional spinning and optical drives, but the mounting pins don't line up with SSDs. There's plenty of space if you do want to add more drives, though, and the fans behind the front door will help to keep them cool if you do.

2 The BitFenix Shadow case we've used doesn't have a side window panel, so while this isn't the tidiest build we've ever done, it's good enough in terms of airflow, and because no one can see inside, it doesn't need to look any better than this.

3 The case comes with a single fan installed at the rear, which we've left in place to help with the overall airflow — important when dealing with a traditional CPU air cooler.

The start of something special

We'll be honest, this isn't a machine that is going to set the world alight in terms of raw performance. When you're piecing together a system using older parts, though, it's never really going to be anything else. You could argue, quite fairly, that a system built with development in mind should use the latest, greatest hardware. After all, when time is precious, scrimping on parts at the build stage will ultimately cost you in the long run. That would be true in a professional capacity, but this was actually built with an intern in mind, and because it uses a lot of older, unused parts, it's essentially free.

The build itself was fairly straightforward, with only the SSD mounting causing any serious head-scratching. The fact that those holes don't line up at all had us wondering whether we were doing something seriously wrong, but we simply couldn't resolve what was happening here. It could be that we were missing some holding brackets, which is a risk you take when you're using older hardware that may not be complete.

When it comes to performance, the machine may struggle to impress when compared to our default zero-point, but it's really not that bad a machine in normal day-to-day use. Those gaming frame rates are generally smooth, and with a few judicious tweaks here and there, you should be able to enjoy games for a few years yet. The *Deus Ex: Mankind Divided* score is low, but that game does appear to thrash even top-end hardware as well — we would have hoped that some optimisations would have materialised by now, but nothing yet.

By the time you read this, AMD Ryzen may be out in the wild, and a quick look at the Cinebench score here shows that it couldn't have come soon enough. To be brutally honest, AMD's Piledriver is miserable when compared to Intel's offerings — even a Core i3 will give this chip a run for its money. At the lower end of the pricing spectrum, this can be forgiven, but at this price, we expect much more. It does have the raw core count when it comes to compiling and handling multiple threads, though, so isn't quite as bad as this benchmark would suggest.

We would recommend upgrading the graphics card, depending on what sort of game development the user intends doing with it, but this is a reasonable enough starting point. Apart from that, the core specification should last a couple of years, and with that large meaty data SSD, there should be plenty of space for textures, videos, models, and anything else needed. A bit more memory wouldn't go amiss, but again, as a starting point, this isn't too bad. The PSU should last a few upgrades as well. ■

BENCHMARK RESULTS

	APC LABS TEST PC	THIS SYSTEM
CINEBENCH R15 MULTI-THREAD	987	532 (-46%)
CINEBENCH R15 SINGLE-THREAD	196	90 (-54%)
CRYSTALDISK QD32 SEQUENTIAL READ (MB/S)	1,895	536 (-72%)
CRYSTALDISK QD32 SEQUENTIAL WRITE (MB/S)	949	514 (-46%)
DEUS EX MANKIND DIVIDED (FPS)	25	15 (-40%)
RISE OF THE TOMB RAIDER (FPS)	76	26 (-66%)
FAR CRY PRIMAL (FPS)	72	35 (-51%)
ATTILA: TOTAL WAR (FPS)	39	20 (-49%)

Our APC Labs test PC uses a Core i7-6700K CPU @ 4.6GHz, an AMD R9 Fury X, and 32GB of RAM. All games are tested at 1080p on max settings, with HD texture packages installed.

Love it or hate it, *Doom* redefined the gaming industry.

Play Doom on your Raspberry Pi

Nate Drake adds a touch of chocolate to your Raspberry Pi through installing a version of this iconic First Person Shooter.

Doom is a landmark in the history of gaming, set in the not too distant future. You are a space marine, exiled to Mars for a dull, routine assignment after striking a superior officer. The Martian Marine Base is secretly conducting experiments into teleportation through creating wormholes between Mars' two moons.

Events take a horrifically dramatic turn for the worse when one of the moons, Deimos, suddenly disappears. Taking the role of the hero of this cyber-tragedy, you are quickly dispatched on a shuttle to the other moon, Phobos. You soon discover that the hapless research scientists have accidentally opened a doorway to Hell itself and that you will have to fight your way through demonspawn, possessed personnel and the forces of darkness to have any hope of escaping.

Despite the retrospectively clichéd plot and clunky graphics, id Software's *Doom* has enjoyed huge popularity since it exploded onto users' PCs in 1993. It helped cement the first-person shooter (FPS) genre of video games as well as spawning a number of official sequels, spin-off games and fan-made levels.

Even those who are too young to remember when *Doom* was initially released will likely be familiar with the FPS genre through the numerous examples around. As *Doom* is the most iconic, it's important to recreate the original '90s experience as closely as possible, and for this reason, we have selected the 'Chocolate Doom' Engine to run on your Raspberry Pi. This project assumes you have a Raspberry Pi 2 or 3, running the latest version of Raspbian. Use `sudo apt-get update` then `sudo apt-get upgrade` to be sure of this. If you want to play Doom's multiplayer Deathmatch mode, you will also need your Pi to be connected to your home network and/or the internet.

GETTING THE LOWDOOM

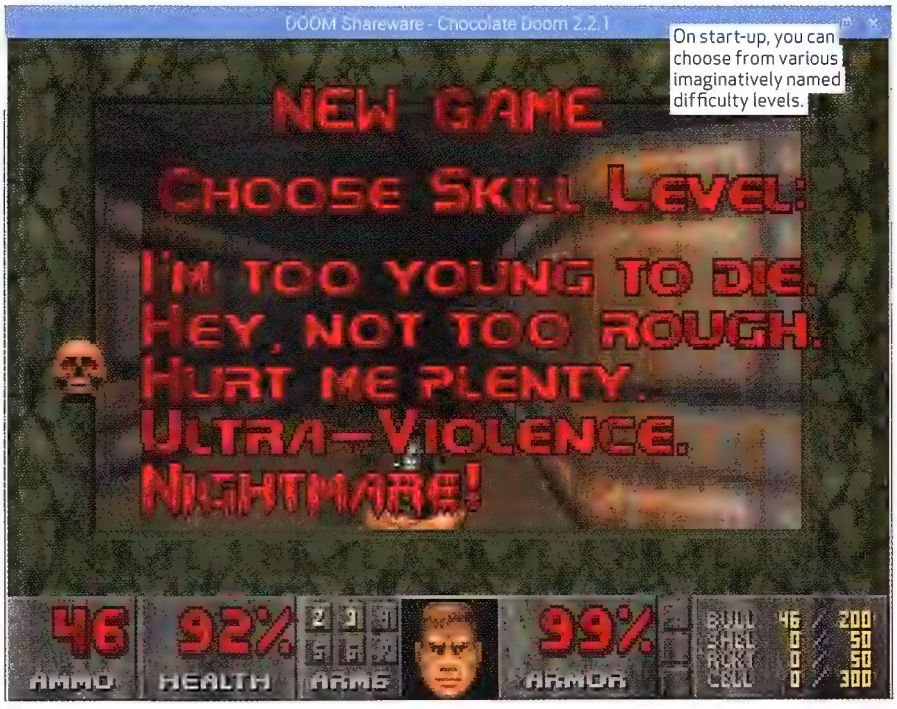
Being a first-person shooter means that all the action is experienced as if you're looking through the eyes of the main character (unnamed in *Doom* but lovingly referred to as 'Doomguy'). The basic premise of the original game is that you must fight through the moons of Phobos, Deimos and then Hell itself. This is accomplished through punching, shooting and even (if you wish) gashing with a chainsaw any zombies, flaming skulls and demonic henchmen that get in your way as you progress through all 27 levels.

The satanic imagery and ultra-violence were not welcomed by several religious groups and political pressure groups, who campaigned in vain to either censor *Doom* or make it more family friendly after its release. Germany banned the game out of hand for containing "bloody, sadistic violence", although this ban was repealed in 2011.

However, there appears to be no such thing as bad publicity. *Doom* sold 1.1 million copies between 1993 and 1999, making it the eighth best selling game of that time. Developer id Software claimed it was probably the number-one cause of reduced productivity globally. This was meant as a joke but, by 1995, there were an estimated 10 million PCs globally with a version of *Doom* installed.

Gameplay is simple in theory if not in practice. On each level, you must locate the exit to the next area. Helpfully enough, these are marked with an exit sign. However, you have to make your way through a maze of levels, identical corridors and locked doors. Some help is available in the form of power-ups, which have been liberally scattered around the place by persons unknown. These include key cards, armour, weaponry and first aid kits. You can also make use of the in-game map by hitting the Tab key to see where you have been. Monsters have an irritating habit of showing up when least expected. They also guard valuable items and exits and have an unfortunate tendency to shoot at you or throw fireballs from a distance.

Although Hell has numbers on its side, the enemy AI is not particularly



On start-up, you can choose from various imaginatively named difficulty levels.

Cheaters never prosper

Chocolate Doom mirrors the original closely, including the built-in cheat codes. These can be used at any time during play, simply by typing them on the keyboard. In most cases, you will see a message confirming that the cheat has been activated. The cheats below assume you're using a QWERTY keyboard.

Cheats can work in multiplayer Deathmatches, depending on the settings made by the person setting up the game — it is possible to add the flag "– nocheats" to prevent others from having an unfair advantage.

All cheats are prefixed by "id", the name of the original game's developer.

A few select cheats in no particular order are:

IDCHOPPERS

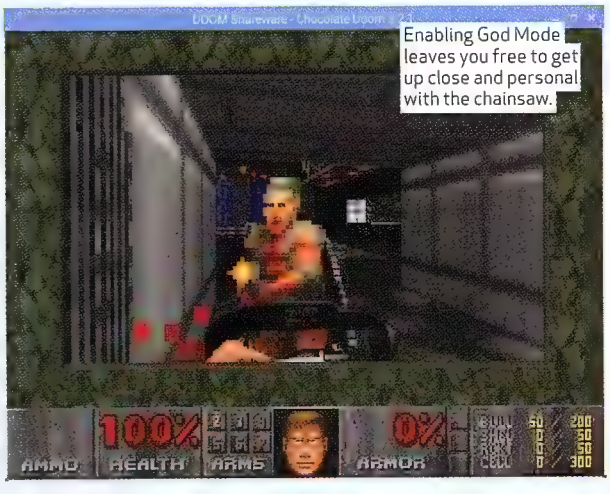
Why shoot the spawn of Hell humanely when you can carve them up with a gardening implement? This cheat will equip you with the chainsaw. Press 1 to select it.

IDCLEV##

Use this cheat code to warp to the episode or map of your choice — for example "idclev02" would take you to Map 2. This has the same effect as starting a new game, in that your health will return to 100% and any power-ups and/or weapons you picked up will be lost.

IDDQD

This cheat sets your health permanently to 100%. This 'God Mode' will make you immune to most forms of damage, though certain types of floors can still harm you. You can also be killed by 'telefragging' — where other players or creatures teleport onto a spot where you're standing.



Enabling God Mode leaves you free to get up close and personal with the chainsaw.

There are plenty more along these lines for the lazy, desperate or perhaps less skilled player. For a full list of cheats, see the *Doom* Wiki at **http://doom.wikia.com/wiki/Doom_cheat_codes**.

Doom Deathmatches

Chocolate Doom supports multiplayer with minimal fuss. Unlike Vanilla Doom, you can play Chocolate Doom either over the internet or via LAN (local area network). To keep things simple, however, make sure all the players who wish to take part are running Chocolate Doom and using the same WAD file before going ahead.

Whether you play multiplayer over the internet or via a LAN, one of the participating players must act as the server and host the game. Rest assured that the host player will be able to play the game, too. UDP port 2342 must be open on each player's router and/or firewall. (See 'The Doom is in the Details' on page 98 for more info.)

To host a Deathmatch game on your Pi, open Terminal or connect via SSH and run the following command:

```
chocolate-doom -server -privateserver
-deathmatch
```

In order to join your game, players should run the following command: `chocolate-doom -connect 1.2.3.4`

Replace '1.2.3.4' with the public IP address of the host player's machine. You can find your public IP by visiting websites such as **http://whatismyip.com**.

For players who are connected to a local network, life is even easier: simply run the game in the usual way but add the argument '-autojoin', for instance: `chocolate-doom -WAD DOOM1.WAD -window 640x480 -autojoin`

The multiplayer window will be displayed, showing the various clients which are connected. Press the space bar when ready to start playing.

Further help for Multiplayer Mode, if you need it, is available from Chocolate Doom's Wiki: **www.chocolate-doom.org/wiki/index.php/Multiplayer**

advanced and they will attack each other if one gets in another's way.

Another advantage is the arsenal of in-game weapons. Although you begin with a pistol, as the game progresses, you can lay your hands on shotguns, chain-guns, plasma rifles and even the unholy BFG (Big F#cking Gun) 9000.

CHOCOLATE AND VANILLA

Both 'Chocolate Doom' and 'Vanilla Doom' are different forms of the Doom Engine. It helps to think of the Doom Engine as been the executable parts of the game, as opposed to the WAD files (see 'Where's all the Data' below) containing raw data like graphics, sound, weapons and so on. The engine handles aspects of the game like the overall structure of levels and movement. The official Doom Engine developed by id is known as 'Vanilla' because of its relatively bland flavour. *Doom* enthusiasts refer to 'Vanilla Doom' to distinguish between the official game engine for running *Doom* and any variants. The distinction is important because the Doom Engine was modified and re-used in several commercial games such as *Heretic* and *Hexen*.

Since id released the source code of the Doom Engine in 1997, a number of community developers have also adapted it to their purposes. Chocolate Doom is one such project.

Despite modifying the game engine, Chocolate Doom aims to reproduce the experience of playing the original version of *Doom* as much as possible. Any modifications to the original game engine do not interfere with the authentic gaming experience. More importantly Chocolate Doom strives to be compatible with all *Doom* expansion files (WADs) that were designed to work with Vanilla Doom.

The only area where Chocolate Doom differs significantly from the original is when playing in the multiplayer Deathmatch mode. One player's machine has to act as a server, unlike in Vanilla Doom where players would connect directly to each other. Fortunately, this is very easy to set up (see '*Doom* Deathmatches' above).

WHERE'S ALL THE DATA?

To play *Doom*, you'll need both the engine and some so-called WAD files. WAD (Where's All the Data) files contain game data such as details of levels, graphics, sound effects and background music. The idea behind WADs is to make it easy for people to make custom levels and modifications for the game. WADs exist separately from game engines such as Chocolate Doom and must be downloaded from elsewhere. There are two main types of WADs. For the purposes of this project, we'll focus on iWADs (short for internal WADs), which contain data for entire levels.

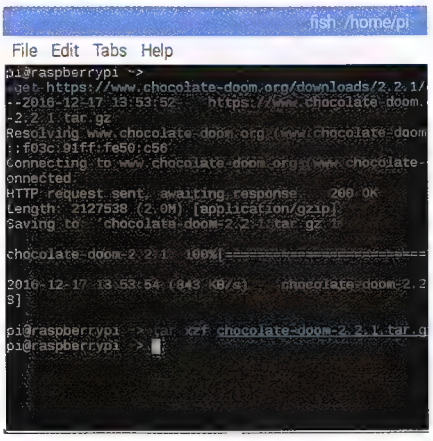
Recipe for Chocolate Doom

1 INSTALL DEPENDENCIES

Your Pi will need certain programs in order to compile Chocolate Doom. Open Terminal from 'Applications > Accessories > Terminal' or connect to the Pi via SSH and install these with the following command:

```
sudo apt-get install libsdl-mixer1.2-dev libsdl-net1.2-dev python-imaging
```

Press 'Y' when asked to confirm that you wish to proceed with the install.



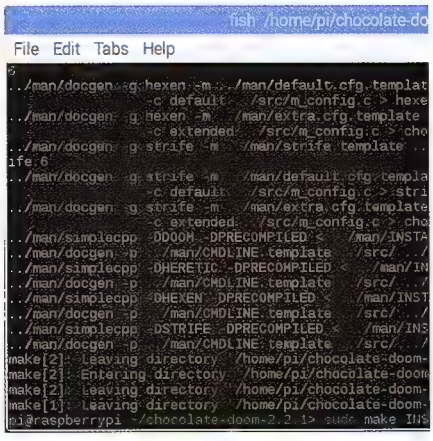
2 DOWNLOAD AND EXTRACT CHOCOLATE DOOM

Fire up your web browser, and head to **www.chocolate-doom.org/wiki/index.php/Downloads** to find the link for the Chocolate Doom Source Code. You can then use the `wget` command in the Pi's Terminal to download it. At the time of writing, for instance, this would be:

```
wget https://www.chocolate-doom.org/downloads/2.2.1/chocolate-doom-2.2.1.tar.gz
```

Once the file has downloaded, extract it using `tar` — for example:

```
tar xzf chocolate-doom-2.2.1.tar.gz
```


fish /home/pi/chocolate-do
File Edit Tabs Help
../man/docgen -g hexen -m ../man/default.cfg.templat
-c default ../src/m_config.c > hexe
../man/docgen -g hexen -m ../man/extra.cfg.template
-c extended ../src/m_config.c > cho
../man/docgen -g strife -m ../man/strife.template ..
../man/docgen -g strife -m ../man/default.cfg.templa
-c default ../src/m_config.c > stri
../man/docgen -g strife -m ../man/extra.cfg.template
-c extended ../src/m_config.c > cho
../man/simplecpp -DDOOM -DPRECOMPILED < ../man/INSTA
../man/docgen -p ../man/CMDLINE.template ../src/ ../
../man/simplecpp -DHERETIC -DPRECOMPILED < ../man/IN
../man/docgen -p ../man/CMDLINE.template ../src/ ../
../man/simplecpp -DHEXEN -DPRECOMPILED < ../man/INST
../man/docgen -p ../man/CMDLINE.template ../src/ ../
../man/simplecpp -DSTRIFE -DPRECOMPILED < ../man/INS
../man/docgen -p ../man/CMDLINE.template ../src/ ../
make[2]: Leaving directory '/home/pi/chocolate-doom-
make[2]: Entering directory '/home/pi/chocolate-doom
make[2]: Leaving directory '/home/pi/chocolate-doom-
make[1]: Leaving directory '/home/pi/chocolate-doom-
pi@raspberrypi ~/chocolate-doom-2.2.1> sudo make INS

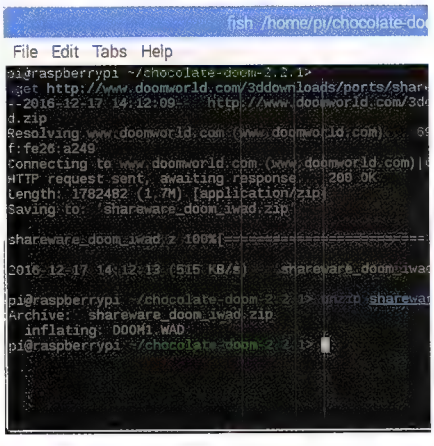
3 COMPILE CHOCOLATE DOOM

Use the `cd` command to switch to the newly created directory:

```
cd chocolate-doom-2.2.1
```

Next, run `configure` to prepare the necessary files. Now run `make` to begin compiling them. This can take some time, so feel free to take a break. Once this has completed, run the following command to actually install the program:

```
sudo make install
```



4 DOWNLOAD WAD FILE (OR FILES)

For the purposes of this project, we will download the shareware version of *Doom*, using `wget` . Make sure you are still inside the Chocolate Doom folder and run the following:

```
wget http://www.doomworld.com/3ddownloads/ports/shareware_doom_iwad.zip
```

Once the file has downloaded, extract it by running the following:

```
unzip shareware_doom_iwad.zip
```

You'll see that the resulting file is called DOOM1.WAD.

5 RUN DOOM SETUP

Use the following command to launch setup:

```
chocolate-doom-setup -iwad DOOM1.wad
```

You can use this to configure the display, sound, keyboard layout, mouse and even a gamepad if you have one. Technically, you can use this screen to host and join multiplayer Deathmatches as well, but it's actually easier just to do this from the command line. See '*Doom* Deathmatches' on the previous page for more information.

6 RUN CHOCOLATE DOOM

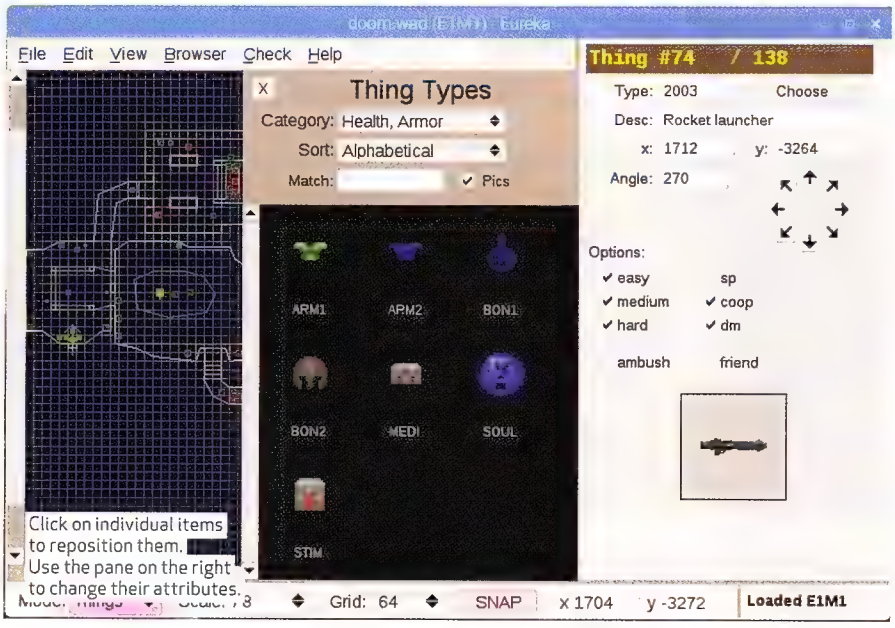
To launch *Doom*, run the following:

```
chocolate-doom -iwad DOOM1.WAD
```

Doom will automatically launch in full-screen mode, which can place a strain on the Pi, so consider opening it in a window with this command:

```
chocolate-doom -iwad DOOM1.WAD -window -640x480
```

If you have a different WAD file, replace DOOM1.WAD with the name of the file of your choice.



When *Doom* initially came out, although enthusiasts were keen to jump on the bandwagon and start creating new graphics, sound effects and so on, they couldn't do much to change some of the game's fundamental values such as how much damage was dealt by monsters. Since the release of *Doom*'s source code and some remarkable efforts by the community at large, however, all aspects of the game can now be changed and there are thousands of WADs. Some of these are simply slight alterations to the game itself, whereas others expand hugely on the premise of the original game. One of the best known of these 'MegaWADs' is Eternal Doom, which contains 32 full levels, each of which is around four times larger than the levels in the original Vanilla Doom.

As impressive as this achievement is, Eternal is simply an expansion of the *Doom* universe. Other WADs are considered "total conversions" in that they replace all resources used in the original game. The first of these was Justin Fisher's awesome Aliens TC, which is based on the eponymous film franchise.

Those interested in working in the industry should not consider designing game levels as a waste of time – Fisher was offered employment by game developer Dreamworks, which he declined in order to finish his university degree. However, other designers of popular WADs such as Iikka Keränen did go on to find employment with major video game companies to work on official projects.

For copyright reasons, in this project, we'll focus on the official shareware WAD of *Doom* (DOOM1.WAD), downloaded from fan site **doomworld.com**. This contains only the first episode of the game, Knee Deep in the Dead, and was initially released to encourage interest in the game. Upon completion of the first level, players were encouraged to order the full version.

This said, there are a number of official and unofficial WADs available for download, so provided it is legal in your jurisdiction, feel free to load and experiment with these.

FREEDOOM ISN'T FREE

The Freedoom Project is an excellent example of the enduring popularity of *Doom*. The stated aim of the project is to create *Doom*-style WADs made entirely of free content. Since id Software has released the source code to *Doom*, the underlying game code is free. Freedoom builds on this with a number of levels, artwork, sound effects and music. The result is a free and open-source game, devoid of any proprietary content.

Freedom provides only WAD files, so needs a compatible game engine in order to be played. The Chocolate Doom website claims that the single player Freedoom WADs are not compatible. It does, however, recommend downloading and playing Freedoom's set of Deathmatch levels known as 'FreeDM'. Unlike the regular deathmatch levels you'll find in Vanilla and Chocolate Doom, the focus is on the players – there are no monsters.

If playing *Doom* has whetted your appetite to try your hand at level design, the Freedoom website also has hundreds of original textures and sound effects that can be used royalty-free. Visit **https://freedoom.github.io** to find these and find out more.

YOUR EUREKA MOMENT

In true Raspberry Pi spirit, you might be one of those who do not want to play with WADs created by others but want to edit and create levels of their own. *Doom* was created to be hacked, expanded and modified, so this is entirely in keeping with game's proud tradition.

Raspbian contains Eureka, the only Linux-based *Doom* level editor under development. Go to 'Applications > Preferences > Add/Remove Software' and search for it using the search bar at the top left, or visit **https://sourceforge.net/p/eureka-editor** to download the software.

Eureka works by editing or creating WAD files, allowing you to write new levels from scratch or change the layout or objects in existing ones. You may find help with using the editor, if you need it, from the **doomworld.com** forums.

THE DOOM IS IN THE DETAILS

For the sake of simplicity, this project has focused on the shareware DOOM1.WAD, which is downloaded to the **chocolate-doom** directory. If your WAD file is located anywhere else, simply specify this when launching Chocolate Doom – for example:

```
chocolate-doom -WAD /home/pi/Downloads/DOOM1.WAD -window 640x480
```

Chocolate Doom is quite pedantic about filenames (capitalisation matters), so if you are trying to locate the WAD file using the Setup screen, you may want to rename your files '.wad' rather than '.WAD'. This is also true for the Eureka Level Editor (see above). During testing, the program failed to recognise the DOOM1.WAD file until it was renamed to 'doom.wad'.

A full list of all command line arguments and further help with Setup are available from the Chocolate Doom User Guide at **www.chocolate-doom.org/wiki/index.php/User_guide**.

In order to play deathmatches in *Doom*, you will need to open UDP Port 2342 on your firewall and/or router. Steps to do this will vary depending on your router. Check with your manufacturer or visit the website **http://portforward.com** for steps on how to do this.

Chocolate Doom sadly is not compatible with the single player Freedoom WAD. You might find other WAD files may not work well or cause issues for your Pi. Ideally, you should have a Pi dedicated to gaming, so there's no risk of losing any data.

On behalf of everyone at *APC*, please also accept our warmest thanks for your efforts in fighting the forces of Hell. Good luck, soldier! ■

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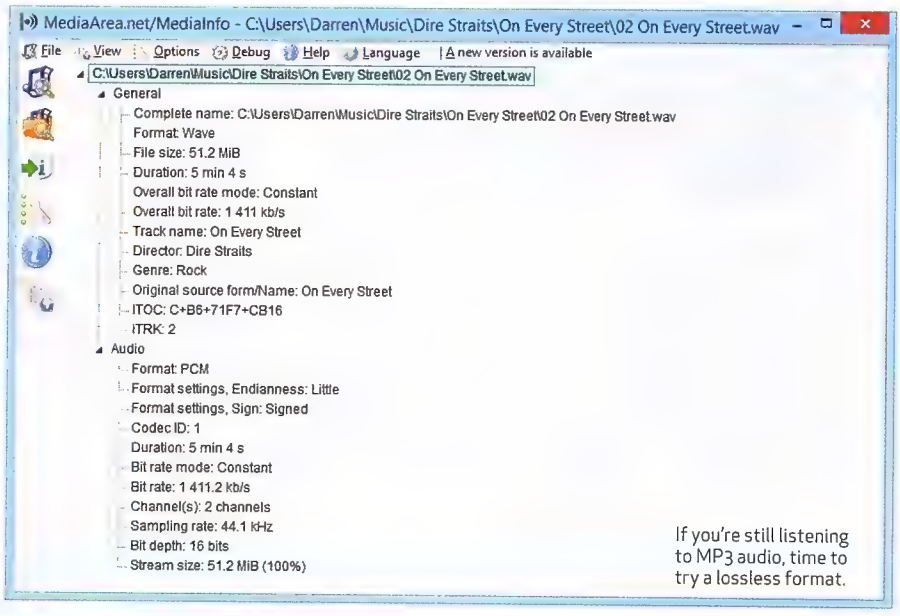
10 ways to improve your Android's audio

Not happy with the sound quality coming from your Android device? Darren Yates has 10 ways to fix it to suit all budgets.

Boil it down and there's not much smartphones can't do. These powerful and portable hand-held computers are already playing high-performance games, recording and playing 4K video, there's not much left for phone makers build in. However, while 'more battery life' is always at the top of everyone's wish list, one area phone makers are now targeting for improvement is audio quality. That's fine if you're ready for a new phone, but what about your current phone if its audio quality is, well, not up to scratch? We've come up with ten ways to hack audio quality and some of them don't cost a cent.


MediaArea.net/MediaInfo - C:\Users\Darren\Music\Dire Straits\On Every Street\02 On Every Street.wav
File View Options Debug Help Language A new version is available
C:\Users\Darren\Music\Dire Straits\On Every Street\02 On Every Street.wav
General
Complete name: C:\Users\Darren\Music\Dire Straits\On Every Street\02 On Every Street.wav
Format: Wave
File size: 51.2 MiB
Duration: 5 min 4 s
Overall bit rate mode: Constant
Overall bit rate: 1 411 kb/s
Track name: On Every Street
Director: Dire Straits
Genre: Rock
Original source form/Name: On Every Street
ITOC: C+B6+71F7+CB16
iTRK: 2
Audio
Format: PCM
Format settings, Endianness: Little
Format settings, Sign: Signed
Codec ID: 1
Duration: 5 min 4 s
Bit rate mode: Constant
Bit rate: 1 411.2 kb/s
Channel(s): 2 channels
Sampling rate: 44.1 kHz
Bit depth: 16 bits
Stream size: 51.2 MiB (100%)
If you're still listening to MP3 audio, time to try a lossless format.

HIGHER-QUALITY SOURCE

Before we start trying more involved hacks, there's arguably not much point if the original source's audio quality isn't up to scratch. Granted, in some circumstances, you may not have a choice, but basically, if you're still listening to 128Kbps stereo MP3 audio, you have to question whether you're really serious. Anything less than 256Kbps MP3 is pointless in my view because you're throwing away too much audio data to make the most of your hardware – you're relying on the MP3 codec and your ears to 'fill in the gaps'.

These days, there are much better alternatives to MP3. For the highest quality, WAV audio can't be beaten because it is the raw pulse-coded modulated (PCM) audio format. However, when factoring in storage space, FLAC becomes the perfect choice (think of it as ZIP file compression for audio) as its native to Android since Honeycomb/3.1. And then there's the 'Hi-Res Audio' (HRA) standard, audio recorded with 96kHz/24-bit sampling or better, that's been slowly gaining fans over the last year or so as new phones arrive with supporting hardware.

Going the other way, use a lossy audio compression format to save space if you must, but at least try a high bit-rate MP3 or Opus. Google added support for Opus in Lollipop/Android 5.0 and in listening tests, it's proven to offer the best perceived audio quality for a fixed bit rate compared with a range of other lossy codecs.

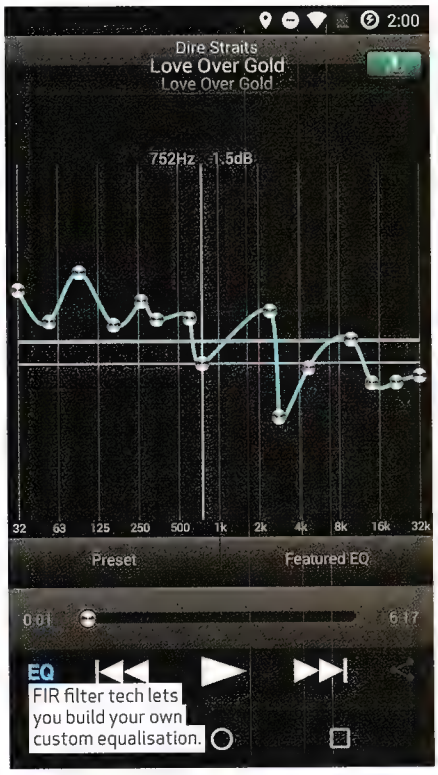
All up, you can't blame hardware for poor audio quality if your source audio isn't great to begin with. And if you have a choice, it shouldn't include 128Kbps stereo MP3 audio.

EXTERNAL USB DAC

We can now establish that audio quality is a combination of the source audio and playback hardware you listen through. When that hardware is your smartphone, however, there aren't always options for hardware-hacking. But if your device supports USB-OTG, you can bypass the on-board

A USB-OTG adapter enables USB DACs to connect to Lollipop devices.

Low-cost battery-powered Bluetooth audio receivers sell for under $20.



"These days, there are much better alternatives to MP3. For the highest quality, WAV audio can't be beaten because it is the raw pulse-coded modulated (PCM) audio format."

audio chain entirely and use your own external audio digital-to-analog converter (DAC). Some audiophiles will demand you spend $200 or more on a decent DAC to get gold-plated quality. However, there are good-quality options using the excellent Burr-Brown PCM2704 DAC chip online for under $20.

Android supports USB audio DACs as standard from Lollipop/Android 5.0, so provided you have at least this OS and your device is USB-OTG ready, you just plug in the DAC via a USB-OTG adapter cable, the phone should recognise it and re-route your audio through it. The beauty of this is your phone sends the audio digitally through to your DAC, ensuring the phone no longer controls the actual sound you hear.

The downside is that the DAC's power comes from your phone's battery, so there'll be a corresponding drop in run-time. But if you're not ready to upgrade to a new phone just yet, this is one way you can overcome below-par on-board audio quality – and provided your next phone also supports USB-OTG, you can take the DAC with you. Just check for any compatibility issues before you purchase.

EXTERNAL BLUETOOTH AUDIO RECEIVER

What if your phone doesn't support USB-OTG? The next option is Bluetooth. Now Bluetooth is commonly used with speaker bars, but you'll also find Bluetooth headphone adapters – a little larger than a USB flash drive, these devices contain a Lithium-ion battery, Bluetooth receiver with built-in amplifier and headphone socket. Instead of connecting straight to your smartphone, you pair your smartphone with the adapter and stream music wirelessly.

You'll find them starting from around $20 or so online, but if you're using powered speakers, you can choose a $5 USB-powered receiver that basically looks like a USB flash drive, while more audiophile-grade models go up to $200. Either way, you plug the USB port into a USB power source, plug the audio cable in between the receiver and your amplified speakers, pair the receiver with your phone and away you go.

The idea, again, is to remove the phone's analog audio circuitry from the quality equation and make the results external to the phone.

EQUALISE YOUR MUSIC

Headphones are a major factor in audio quality, but if your budget won't spring for a new headset, try attacking the problem from the other direction. How you perceive audio quality is a function of your phone hardware, your headphones and your ears – and none of them are perfect. Using EQ (equalisation) allows you to vary different frequency components of the audio to equalise or balance out perceived peaks and troughs in the audio spectrum and get a better sound.

The great thing about EQ is there's no right answer – only what sounds right to you. However, if you're correcting budget headphones,

Audioengine's B1 high-end Bluetooth audio receiver sells for around $250.

Cheap $5 Bluetooth audio receivers add wireless to any powered speakers.

Low-cost USB DACs with Burr-Brown chips work with Lollipop Android.

Sony's Xperia XZ phone supports Hi-Res Audio.

LG's V20 phone has ESS Tech's quad-DAC chip for lower noise.

"The downside with using EQ is that, depending on your phone, it may well be the CPU that has to do the work, which may also affect battery life."

chances are the bass levels will need boosting below 300Hz, the mid-range somewhere around 2–4kHz will need minor trimming and the high frequencies above 6–8kHz will need minor boosting. Start there and see how you go.

The downside with using EQ is that, depending on your phone, it may well be the CPU that has to do the work, which may also affect battery life. However, more modern phones outsource EQ processing to dedicated chips, reducing power consumption. Try some 'before' and 'after' testing to see how your phone performs.

CHECK AUDIO SIGNAL LEVELS

OK, this may sound weird, but go with me for a bit. To get sound from your phone to your ears, the last stage it passes through before reaching the headphone socket is the audio amplifier circuitry. Now without diving deep into audio amplifier design theory, the sound you hear coming from the headphones is a function of the output signal voltage from the amplifier and the impedance of the headphones.

All headphones have an impedance, or resistance to audio signals, but it varies between models – 32ohms is common, but you'll also find 250ohm and 600ohm headphones. Lower-impedance headphones are easier for smartphones to drive, meaning you will likely get a higher output level than using higher-impedance headphones. You'll also likely try to push the output level higher on these higher-impedance headphones to get a listenable audio level.

Just beware that, the higher you push the audio level, the closer you may get to creating clipping distortion. This occurs when the digital value of an audio sample reaches 'full scale', with no room to move higher and 'clips'. If you use software tweaks that allow you to boost audio levels, for example, using EQ with added gain, it's possible to push those levels into this 'clipping' territory, adding truckloads of distortion. So be wary using EQ gain – too much doesn't always help.

CHANGE YOUR MUSIC PLAYER

This sounds pretty obvious, but many users just stick with the default music player app and think "That'll do!" However, few default players include equalisation and if you're hoping to improve your phone audio at zero cost, EQ has to be on your must-try list.

Everyone seems to have their favourite player, so here's mine. The Onkyo HF Player on Google Play from audio specialists Onkyo gets my vote because it has one of the best equalisers you'll find in an Android app that doesn't require root access. It's build on a digital-signal processing (DSP) technique called 'finite impulse response' (FIR) filtering, which effectively lets you specify the frequency band and amplitude change of the audio you want to modify. The Onkyo HF Player takes this to the extreme by incorporating up to 16,384 bands and turning them into a fully-customisable equaliser you create by drawing the precise frequency response you want on the screen. Compared with most fixed full-octave EQ options that might give you ten frequency bands to play with, this is the ultimate in frequency-response control.

Again, the downside is that the mathematics required to implement those FIR filters requires extra CPU cycles, so your device battery life might drop a bit, depending on the CPU and battery capacity of your device. But if you want to try to overcome poor audio with little-

to-no outlay, FIR-filter equalisation is the best way I know.

TRY SOME AUDIO MODS

If you're seriously hard-core about your audio and you have an Android device that has root-access, you can try some of the audio effects libraries floating around specialist Android websites like xda-developers (**xda-developers.com**). Two popular options are Viper4Android and A.R.I.S.E. SwanSong.

Viper4Android provides a dizzying array of audio filters and options, including different forms of surround, such as field and differential, as well as reverb. It includes FIR-filter equalisation like the Onkyo HF Player, but also adds extra features such as automatic gain control (AGC) to auto-adjust levels when listening on speaker.

Swansong takes Viper4Android a step further, bundling a whole new series of audio FX and profiles. This is as hard-core as audio-modding gets and isn't for the feint-hearted or those who count down the remaining days of device warranty.

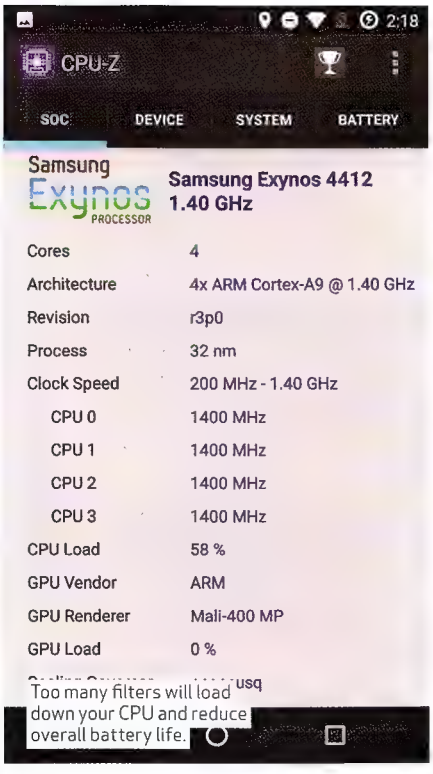
WARNING: SwanSong has to be flashed to your device and, once installed, it can't be completely uninstalled unless you re-flash your phone ROM. In other words, try these options at your own risk. In both cases, read up on their install requirements before proceeding.

AVOID TOO MANY FILTERS

But on the other hand, you can't guarantee adding a bunch of audio filters will somehow result in perfect sound. It may colour it, it may mask it so that you perceive it to sound better, but every time you fiddle with audio, you are modifying it and you can't guarantee it'll actually help.

When it comes to audio amplifier design, the ideal is to pass the audio through as few stages and through as few processes as possible, so that you have fewer opportunities to affect the audio quality – whether it's by adding electrical noise, total harmonic distortion (THD), intermodulation distortion (IMD) or just straight-out clipping. But equally, passing the audio through numerous filters can also change its flavour.

The purists will always tell you if you want the cleanest audio quality, do as little to the audio signal as possible.



GET BETTER HEADPHONES

Now please don't read this as 'get expensive headphones'. While many earphones supplied with smartphones are probably best left to landfill, it'd be fair to say that a number of headphone models available on the market appear to focus on style over substance. If you want to look like a rock-god with a hip brand, fine, go for your life – but don't assume more cash always buys you better sound.

From a technical perspective, I avoid headphone models with extra bass or top-end boost – the ideal headphones reproduce all frequencies equally (or have what's called a 'flat frequency response'). Any audio engineer worth their salt will create the right mix without requiring peaky headgear.

And finally, open-back headphones don't block sound, so remember your fellow bus or train passengers when setting the audio level.

GET A BETTER PHONE

But if none of that works, it might just be time to fork out for a new phone. Yep, that sounds like the mother of all copouts, but there's been quite a bit of work going into some recent high-end Android phones. For example, LG's recent V20 smartphone features a new audio DAC design called a 'Quad DAC', which combines four 32-bit DACs in parallel for each audio channel. According to chipmaker ESS Technology, the ES9218 audio SoC delivers increased signal output and reduced background noise as a result, pushing the signal-to-noise ratio (SNR) to an impressive 125dB.

Rumours are the new LG G6 phone also features quad-DAC tech. But another less-known feature in these chips is the 2-volts RMS output amplifiers. This higher-level output provides greater drive for premium high-impedance headphones, something some phones struggle with.

At the end of the day, there's really no excuse for listening to dodgy audio. Regardless of your budget, there are a number of techniques available that may just help squeeze some extra enjoyment from the gear you've already got.

And some of these tweaks will cost you nothing to try. ■

Sennheiser's 2.20s folding headphones are designed for smartphone use.

The Tiny-est Arduino

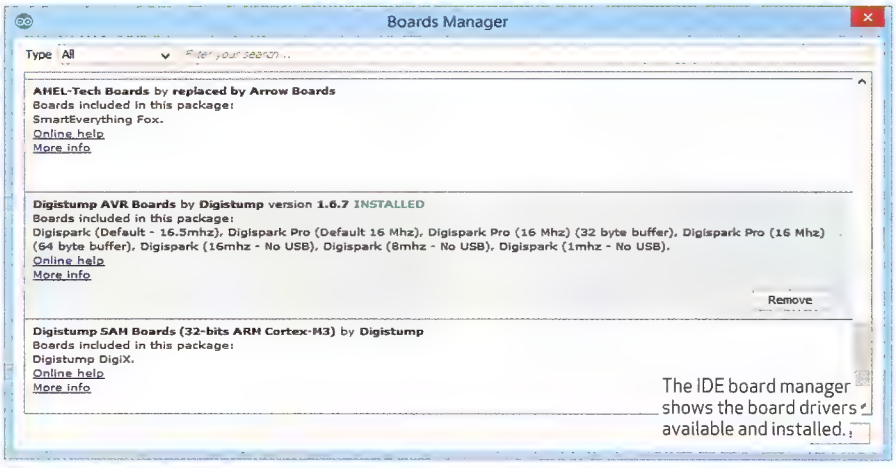
No larger than an SD flash card, the Digispark is a tiny microcontroller for tiny jobs. Darren Yates explains how to code it with the Arduino IDE.

Technology is all about miniaturisation, so it's not surprising there are always smaller microcontroller boards appearing on the market. But even the Nano has its work cut out keeping up with one of the smallest microcontroller boards you'll find – and what's more, you can code it with the same Arduino IDE.

ATMEL ATTINY85

The Digispark board, from tech start-up Digistump, began as a successful Kickstarter campaign and combines the tiny Atmel ATTINY85 microcontroller onto an equally small circuit board the size of an SD card. While it has most of the same 8-bit architecture as the ATMEGA328P powering the Arduino Uno and Nano boards (including the same 16MHz clock speed), the 8-pin ATTINY85 chip has a quarter of the ATMEGA328P's RAM and flash storage.

Now having only 8KB of storage and 512-bytes of RAM to work with might sound like a real downer, but you'll be surprised at the ingenuity being shown with this little device. So far, we've seen microSD card storage, OLED panels and sensors galore hanging off these things. And with its I/O pins all down one edge, it makes plugging into a small breadboard nice and easy.


Boards Manager
Type All
Filter your search...
AMEL-Tech Boards by replaced by Arrow Boards
Boards included in this package:
SmartEverything Fox.
Online help
More info
Digistump AVR Boards by Digistump version 1.6.7 INSTALLED
Boards included in this package:
Digispark (Default - 16.5mhz), Digispark Pro (Default 16 Mhz), Digispark Pro (16 Mhz) (32 byte buffer), Digispark Pro (16 Mhz) (64 byte buffer), Digispark (16mhz - No USB), Digispark (8mhz - No USB), Digispark (1mhz - No USB).
Online help
More info
Remove
Digistump SAM Boards (32-bits ARM Cortex-M3) by Digistump
Boards included in this package:
Digistump DigiX.
Online help
More info

The IDE board manager shows the board drivers available and installed.

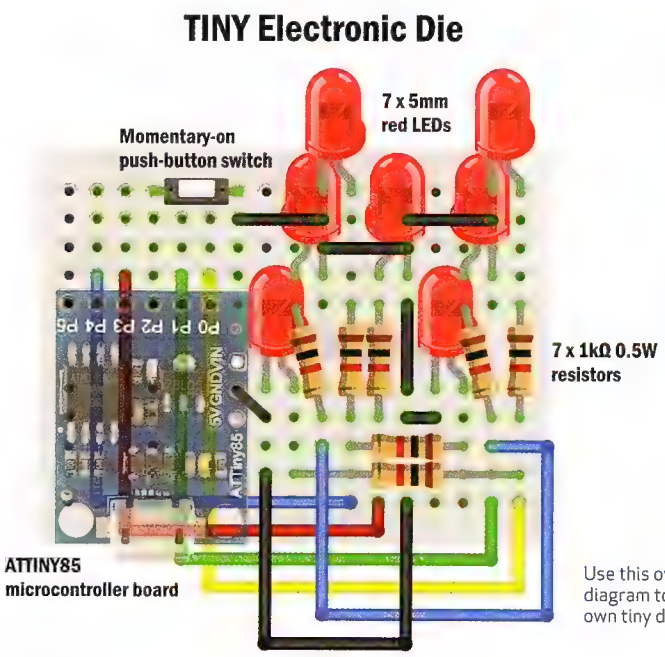
PLENTY OF FEATURES

In fact, the amount of features it's possible to squeeze into six I/O pins is extraordinary. Despite the pin-count handicap, it still manages to include SPI (serial peripheral interface) and I2C (inter-integrated circuit) bus support, has four analog-to-digital converter (ADC) inputs and can output pulse-width modulation (PWM) signals on four of its outputs. Plus, it has microUSB port hardware built right into the chip – not even the Nano has that!

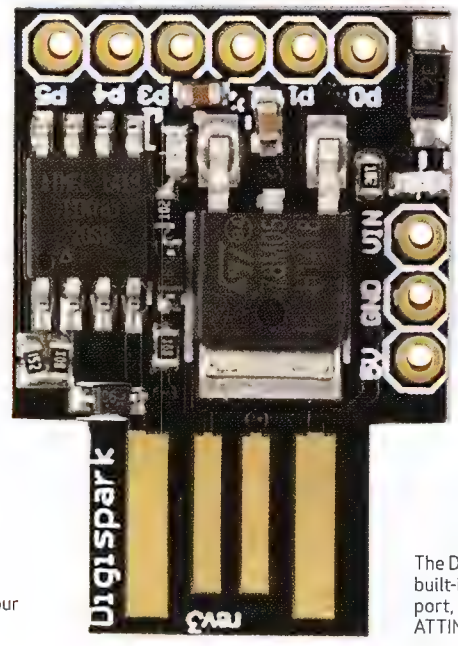
TWO VERSIONS

The official Digispark board comes with its own built-in Type-A USB port formed from the circuit board. This is pretty cool because it means you don't need any cables, just a spare port and you're ready to go. The other version you'll find replaces the circuit board USB port with a microUSB port instead, which makes it look like an anaemic Arduino Nano.

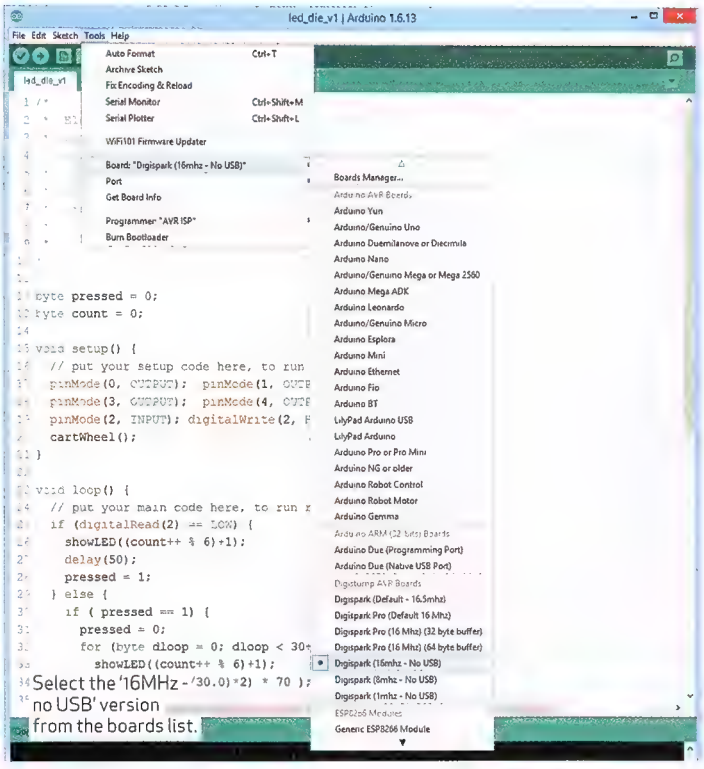
They both work the same way, otherwise, with the same six I/O ports and three power supply pins (Vin, 5V and GND). Both boards run off 5VDC natively, but have an in-built voltage regulator able to take up to 12VDC input. The I/O pins are designed for 5V input.

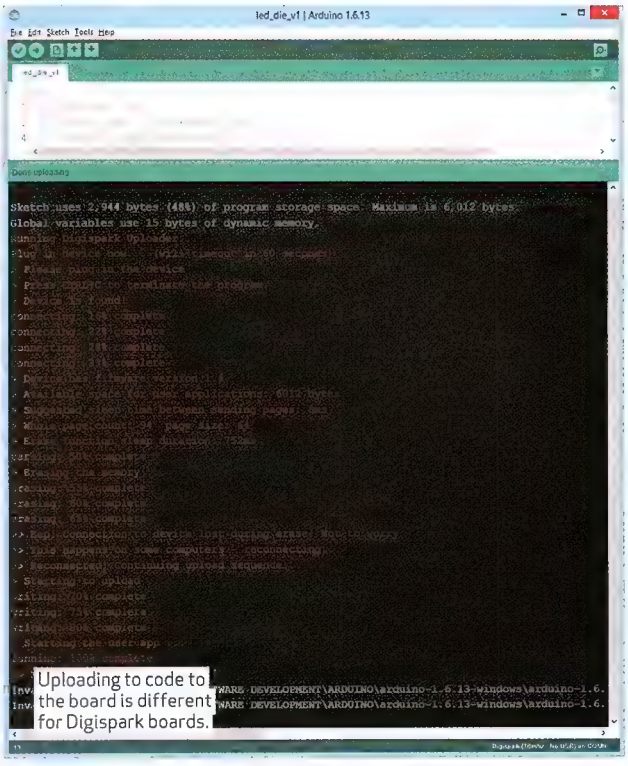


Use this overlay diagram to build your own tiny die.



The Digispark has a built-in Type-A USB port, runs the Atmel ATTINY85 chip.





PROJECT: Simple electronic die

This month, we thought we'd give it a simple task of creating a pushbutton-activated six-sided electronic die on a tiny 170-point breadboard. The seven LEDs are arranged to show the faces of a die – press and hold the button and the die will 'roll', quickly cycling through the six 'faces'. Let it go and the 'roll' will slow to a stop to reveal the 'up' face. After five seconds, the LEDs will go out.

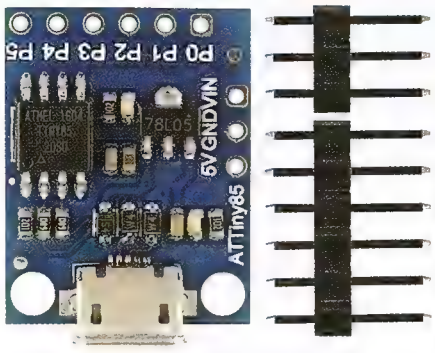
It's pretty simple, but you can power it with any USB port, USB phone charger or power bank. It consumes around 20mA of current (40mA peak when the LEDs are lit), so should run for ages on a single charge, depending on battery capacity.

BUILDING THE BREADBOARD

All you need for this is the 170-tiepoint breadboard, either of the two Digispark boards (we used the microUSB version), seven red LEDs, seven 1kohm 0.5W resistors, some tinned-copper wire for links and a few jumper wires. We sized and trimmed the legs of the LEDs and resistors (the excess trimmed legs can be used for wire links). To fit everything in, the LEDs are slightly offset vertically, but it still does the job. Follow the overlay diagram to build your own.

SETTING UP THE ARDUINO IDE

Building it should take no more than 30 minutes, even if you're really slow. Normally, flashing code to an Arduino board is a matter of setting up the COM port, selecting the correct board type and pressing the IDE's Upload button. However, coding the Digispark board requires a little more patience, as things here are done a little differently.



This alternate version features a microUSB port, but is functionally identical.

For starters, the Arduino IDE knows nothing about the ATTINY85 microcontroller chip, so first things first, we need to import the code library. Launch the IDE (get it from **arduino.cc**), select 'File > Preferences' and in the 'Additional boards manager URLs' text box, add:

```
http://digistump.com/package_
digistump_index.json
```

You can have more than one entry on that line, so if there's text there, click the box on the right and enter the link on a new line. Press OK. Back on the main screen, select 'Tools > Board > Boards Manager'. When the new window appears, set the Type combobox at the top-left to 'Contributed' and look for 'Digistump AVR boards' in the list. Click on the entry, move to the right and select the 'Install' button.

Once complete, you should see the Digistump Windows driver installer appear – allow it to install. When done, restart the Arduino IDE.

FLASHING CODE TO THE BOARD

Now the Arduino IDE knows all there is about Digispark, you're ready to flash the board with code – but things here are a bit different, too. Normally, you'd preset your options first, plug in your board, then click the big green 'Upload' button, wait for the code to shoot through and you're ready to go. But with Digispark, you select the board in the 'Board' settings (we used 'Digispark 16MHz – no USB' in our example), hit the green 'Upload' button, then plug in the board when prompted by the status box. If you're a long-time Arduino user, it feels weird doing it but it does work, so just be patient. It'll take a few seconds before the IDE recognises the board and begins flashing your code.

Once the flash process is complete, unplug the board, plug it into your project and you're away. If you're building the electronic die here, you should see a 'cartwheel' spin on the LEDs about five seconds after applying power. It's then ready to roll.

GET MAKING!

You'll find the source code for this project at our website (**www.apcmag.com/magstuff**). Unzip it, load the 'led_die.ino' source code into the IDE and follow the instructions detailed above.

There is plenty of cool tech gear on the market, but none of it will ever mean as much to you as the tech you make yourself, whether it's learning to flash LEDs or making your own robots.

Start with the basics, grow your coding muscles and you won't look back.

Low-cost bundled retro consoles are all the rage right now.

Make your own games in Python

Ready to take the ultimate Python coding step? Darren Yates explains how you can create your own simple games with Pygame.

It's pretty hard to escape the 'retro-gaming' boom at the moment – the success of the NES Classic Edition has also given light to other classic console rebuilds, such as the sub-$100 Atari Flashback series and the Sega Mega Drive retro issue you'll find in discount retailers, all with a swag of built-in games to remind us how fun sidescrollers and platformers were back in the 1970s, '80s and '90s. The simpler 8/16-bit graphics are still as enticing as they were all those years ago and show that being popular doesn't require a hard drive full of triangles.

The Python programming language may have a diverse range of occupations these days, but it isn't averse to surprisingly good gaming, thanks to the popular Pygame module.

INTRODUCING PYGAME

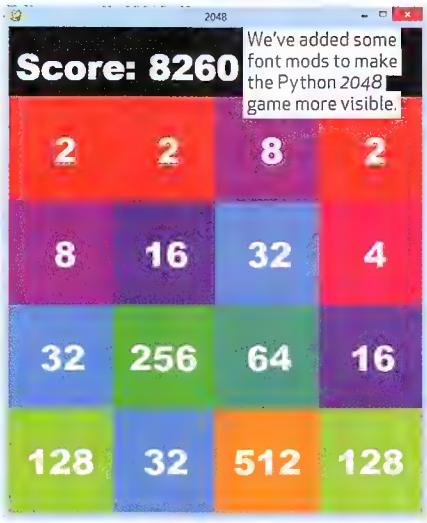
You can write games in any computer language, but Python's popularity means that gaming functionality is pretty well advanced here. Now to be sure, you can code games in Python straight off the bat, but to make things easier, a whole bunch of multimedia modules, functions and extras have been combined into a collection called 'Pygame'. It's not part of the basic Python installer you download but, once installed, you can begin taking advantage of its functionality through an 'import' statement at the top of your code.

Because Python is an interpretive language (meaning it runs within an interpreter rather than being compiled into machine code prior to operation), it's estimated to be a good order-of-magnitude slower than C-based code, so Pygame uses the SDL (Simple DirectMedia Layer) library, which is full of fast C-code, to speed up time-critical components and provides links or 'hooks' for you to attach your Python code. The result is speed and simpler code where you need it.

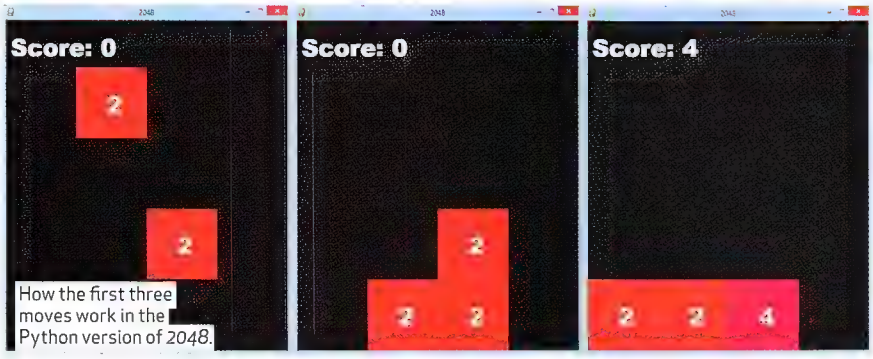
INSTALLING PYGAME

Pygame runs on Windows, Linux and

The popular *2048* puzzle game has been ported to Python via Pyjama.



We've added some font mods to make the Python *2048* game more visible.



How the first three moves work in the Python version of *2048*.

One of a number of Android versions of the *2048* puzzle game.

Mac OS X (meaning its cross-platform), but we'll confine ourselves to just working in the Windows domain. Even so, installing it is a bit trickier than just double-clicking on an installer file. One of the utilities included in the Python Windows distribution is 'Pip', Python's package manager. It runs at the command prompt and we'll use it to install Pygame.

If you haven't already, download and install the latest Python 3.6.x for Windows from **python.org**. Next, we recommend you download the latest appropriate version of Pygame from the University of California's Laboratory of Fluorescence Dynamics, mainly because they not only house an extraordinary collection of Python libraries, but they also have the latest pre-built Pygame packages or 'wheels' ready to install (head to **tinyurl.com/3dlndgh**).

Beware, though, as there are different options depending on your versions of Windows (32 or 64-bit) and Python (2.7, or 3.4, 3.5 or 3.6). If you're using the standard 32-bit Windows version of Python 3.6, at time of writing the file you needed is 'pygame-1.9.3-cp36-cp36m-win32.whl'. These '.whl' files are known in Python as 'wheels' and are basically a modified zip file (they're also kind-of like 'deb' archives in Debian Linux if you're coming from there).

To get Pygame into a Windows' version of Python so it knows where to find it, the easiest way is to first copy the pygame.whl file you downloaded to Python's Script folder (c:/users/<name>/AppData/Local/Programs/Python/<PythonVersion>/Scripts).

Once you've done that, start a command prompt in that 'Scripts' subfolder (use Windows Explorer, open the folder, hold the Shift key down, right-click in the file pane and select 'Open command window here' from the context menu). Now in the command prompt, run the command:

```
pip3 install pygame-1.9.3-cp36-cp36m-win32.whl
```

...(or your particular version of the Pygame wheel) and allow it to do the rest. You should get a 'successfully installed' message if everything has gone smoothly. If you do, you can now run a simple test in the Python Shell. Type:

```
import pygame
```

...and press Enter. If you get no error messages, congrats – Pygame is installed and ready to work. The good news also is you only have to do this process once (at least only once for each major Python release and any Pygame updates you choose to install).

WHAT CAN PYGAME DO?

Unfortunately, we don't have a hope of covering everything Pygame can do in a few short pages, but there are some pretty impressive executions to show what is possible.

Pygame has been around since 2001 and, in that time, it's built up a pretty solid following, particularly for platformers and sidescrollers. One of the best I've seen so far is a Pygame implementation of *Super Mario Bros* Level 1 by Justin Meister (**tinyurl.com/pcemwbo**). It's meant for 'educational purposes only', but if it isn't pixel-perfect, if it'd have to be damn close, right down to the well-known 8-bit soundtrack.

If you look over at the pygame.org website (**pygame.org/tags/all**), you'll find a showcase of games at various stages of completion. What's great about this is getting to look at any available source code – reading and tracing through source code is one of the best ways of growing your coding muscles and understanding how a language or feature works (short of starting your own work from scratch).

As we've said many times before, rarely is there one way something must be done, so if you're interested in trying out Pygame and writing your own games, read Pygame source code, plus the documentation and tutorials, as your way into coding. You'll find everything over at pygame.org.

THE 2048 GAME

One of my new favourite games is *2048* (OK, so I missed the bus on this one), a cool sliding block puzzle game that's

incredibly addictive and great for learning binary numbers. If you haven't seen it before, I'll apologise now for the time you'll spend playing this addictive game. The premise is simple enough – move the tiles until you get two like-value tiles next to each other. Move them again in that plane and they merge into a single tile with the value of the two. Each move also adds another base-level '2' tile to the puzzle.

Yes, it's a clone of *1024* and you could argue even 'Threes', but it's available in everything from Android to iOS, browsers, there's even a version of the Nintendo 3DS. The original *2048* source was written by Gabriele Cirulli in Javascript, which has enabled it to now adorn webpages everywhere (you'll find the source for his version at **gabrielecirulli.github.io/2048**). But you'll also find a number of Python ports on the web and one I want to take a quick look at is available on GitHub by Lewis Deane (**tinyurl.com/hc3c2cl**). This particular version is roughly 300 lines of code, but once you get into it, it's not too difficult to follow. It's actually a nice intro into the basics of Pygame and how to use it for simple games (got to crawl before you can walk).

As you can see from the pics, we've found a couple of small, easy modifications to the code that make it a little easier to read, by changing the value label font from a thin 'monospace' to a larger, thicker 'Arial Black'. You can do this by changing lines 21 and 22 from:

```
  myfont = pygame.font.
SysFont("monospace", 25)
  scorefont = pygame.font.
SysFont("monospace", 50)
```

...and making them:

```
  myfont = pygame.font.
SysFont("arial_black", 50)
  scorefont = pygame.font.
SysFont("arial_black", 50)
```

The other change is modifying how those value labels are positioned on the tiles. The tile labels show '2', '4', '8' and so on, but as the values can span up to four digits (as in '2048'), the code author uses a simple offset code-branch in the `printMatrix()` function to move the horizontal start position of the value labels as appropriate. The original settings were designed for a 25-point monospace type, but to work with our wider 50-point Arial Black font, the 'offset' values need to be changed from -10, -15, -20 and -25 to -10, -30, -50 and -70 in code lines 98 to 104, respectively, in the 2048.py file.

The overall result might not be to everyone's taste, but I find it easier to read. In any case, that's one of the points of learning to code – if you have an app's source code, you can modify the thing to suit your own individual needs.

PYGAME INTRO

The *2048* game obviously doesn't push Pygame all that hard, but it's enough to get us started and learn the basic flow. The thing to remember is that this is still Python, so for the most part, you still control the functional code and flow of your game. You could probably do this game without Pygame, but again, it gives us a gentle intro.

What Pygame essentially does in this instance is handle all of the Windows application programming interface (API) calls to display windows, labels, shapes, colours, capture keyboard key-presses and so on, allowing us to just deal with coding the actual game.

The first step is importing the Pygame module into your game, using the line:

```
import pygame
```

Next, you have to initialise it, using:

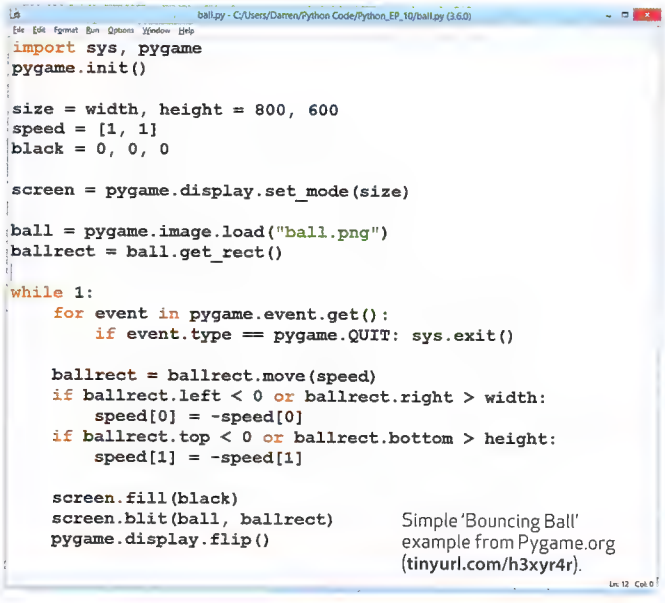
```
pygame.init()
```

From there, you can now set up a display panel, what Pygame describes as a 'surface', and set the pixel size of the surface to whatever you want to work with. For the *2048* game, the codeline involved is:

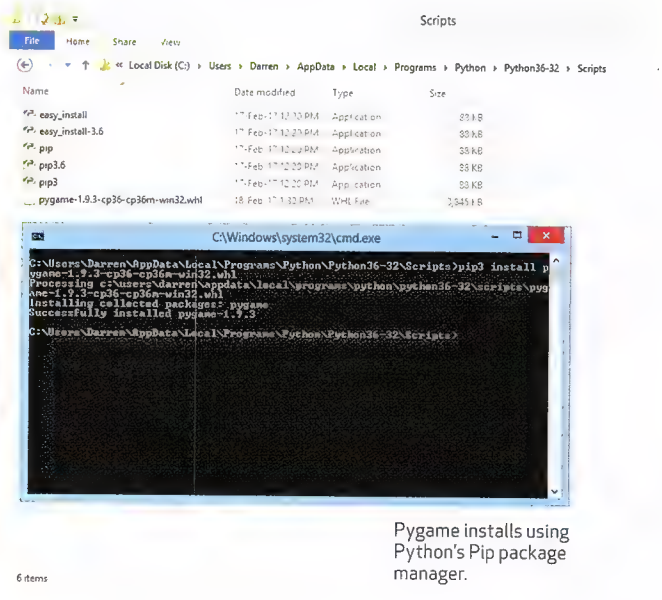
```
  SURFACE = pygame.display.
set_mode((600, 700), 0, 32)
```

So the game area is 600 x 700 pixels, the '0' indicates any additional control signals or 'flags' used (none) and the colour-depth is 32-bit, although these last two parameters are optional.

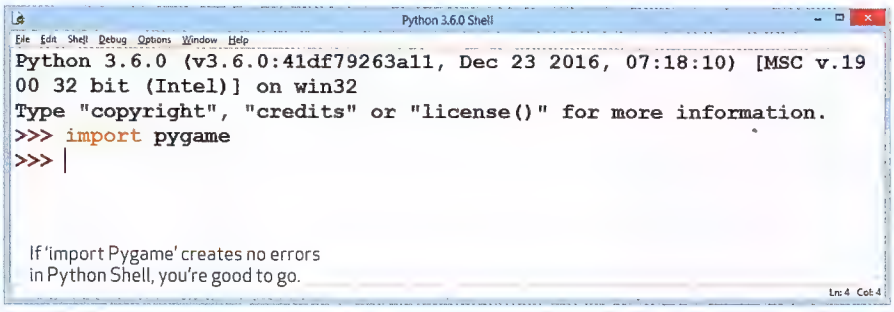
> "That's one of the points of learning to code – if you have the app's source code, you can modify the thing to suit your own individual needs."



Simple 'Bouncing Ball' example from Pygame.org (**tinyurl.com/h3xyr4r**).



Pygame installs using Python's Pip package manager.


Python 3.6.0 Shell
File Edit Shell Debug Options Window Help
Python 3.6.0 (v3.6.0:41df79263a11, Dec 23 2016, 07:18:10) [MSC v.19
00 32 bit (Intel)] on win32
Type "copyright", "credits" or "license()" for more information.
>>> import pygame
>>>
Ln: 4 Col: 4

If 'import Pygame' creates no errors in Python Shell, you're good to go.

This Pygame version of level 1 of *Super Mario Bros* is pretty decent.

EVENTS

From here, Pygame's involvement in *2048* is mostly monitoring actions or 'events'. Events are triggers for further actions, for example, an event can be a key pressed (or released) on the keyboard, it can be a mouse-button, you can even create your own 'userevents'.

Look at the *2048* code's `main()` `function` and you'll see that much of it is located within a while-loop. The condition for this loop is 'True', which means it just loops continuously.

The first line within the while-loop searches the current stack of events using a for-loop:

```
for event in pygame.
event.get():
```

An event is recorded by Pygame and stored in an event stack. While there are no events recorded, the code flow skips the for-loop since 'pygame.event' is empty. But as soon as an event is logged, this for-loop is activated.

Now for each event found in the stack, we want the game to do something. In the case of *2048*, that 'something' is moving and controlling the game tiles based on the direct of the keyboard arrow-key pressed. The event for a key-press is 'KEYDOWN' and once detected, further code then checks to see which key was pressed and performs the appropriate action.

All of the basic code features you see in this game – for- and while-loops, if-then conditionals, functions – we've covered in our Python Masterclass over the last few months, so long-time readers should be able to follow it relatively easily.

One thing I always find helpful at this point is to slowly step through the game code, particularly when it's a tile slider like *2048* with discrete game steps and just mentally process what the code does each time you press a key – it's one of the best ways I know for getting a quick understanding of what the code does and how it works.

From here, Pygame comes with a stack of useful functions ideally suited for platform games, particularly 'sprites', two-dimensional graphical assets you can control as part of your game, plus collision-detection or being able to detect when two objects enter the same pixel space or 'collide'. Through SDL, it can also take advantage of GPU hardware acceleration for extra game graphic performance (although not on all platforms).

TRY IT OUT

Pygame isn't the last word in Python gaming, but if the idea of manually developing your own sprite and tile structures and code is driving you loopy or you're just struggling to get that game idea out from your head and into your computer, give Pygame a whirl. You'll find all the documentation at the Pygame.org website, along with a number of intro guides to get you started (**pygame.org/docs/tut/pygameIntro.html**). There's a neat little tutorial on that page that shows how to create a bouncing ball within a surface in just a handful of code lines.

What's great about learning Python is that, once you get the basics under your belt, you can start moving freely between the many coding groups that build their work around this excellent coding language. So what are you waiting for? ■

The Nintendo Classic Mini, poster-child for budget retro-gaming.

Horizon sets a new graphical high watermark for consoles. It looks incredible at 4K on the PS4 Pro.

apc HOT PRODUCT

PS4 | $99.95 | WWW.GUERRILLA-GAMES.COM

Horizon Zero Dawn

Supreme sandbox exclusive is a metal marvel.

Guerrilla should never make another *Killzone*. The Dutch studio spent nine years delivering dreary sci-fi shooters. Spend nine minutes with *Horizon Zero Dawn* and you'll appreciate how head and shoulders above the Helghast the dev's new IP is. This is a sensational sandbox – and one of the best open-world games in years.

People routinely moan that modern games merely look prettier than titles of the past, rather than evolve the gameplay. That's not a critique you can lay on *Horizon*. The emergent behaviour systems of the robo-dinosaurs makes you feel like anything is possible. Witness two 45-foot AI alligators emerging from a river, a tribe of hunters whaling on them with spears, as a Pteranodon-dwarfing Stormbird pelts the lot of 'em with electric bolts, and then tell us this could have been done on PS3.

The key facts: embattled human factions eke out an uneasy existence alongside a bevy of AI animals known as the Machines (that'd be the aforementioned robo-dinosaurs). Yes, this is yet another dystopian world ravaged by war... wait, come back! For fear of spoilers, we won't delve into specifics. Just know this: *Horizon*'s story is not what you're expecting.

Aloy is a really interesting lead, especially by sandbox standards. She's no generic criminal seeking redemption. Instead, Aloy is a compassionate paradox who simply wants to know where she came from... in between shooting arrows at mechanical hippos.

Stripped down *Mass Effect*-esque conversation wheels give you multiple dialogue options while taking on missions, allowing you some agency. Choosing between confrontational, compassionate, or intelligent answers doesn't have much of an impact on how the story plays out, but it's still nice to have control over the RPG-lite responses.

Stalking robotic creatures to harvest their valuable parts, then trading them in for shards (the game's currency) and weapons upgrades; clearing out bandit encampments with predatory, impeccable sneaking; reminiscing about Shadow Of The Colossus as you figure out how to scale a Longneck to reveal new areas of the map... there's a wealth of diversions on show. All this monster mayhem features prominently in the game's central story missions and abundance of sidequests, and both are granite-strong.

Say hello to PS4's new killer franchise.

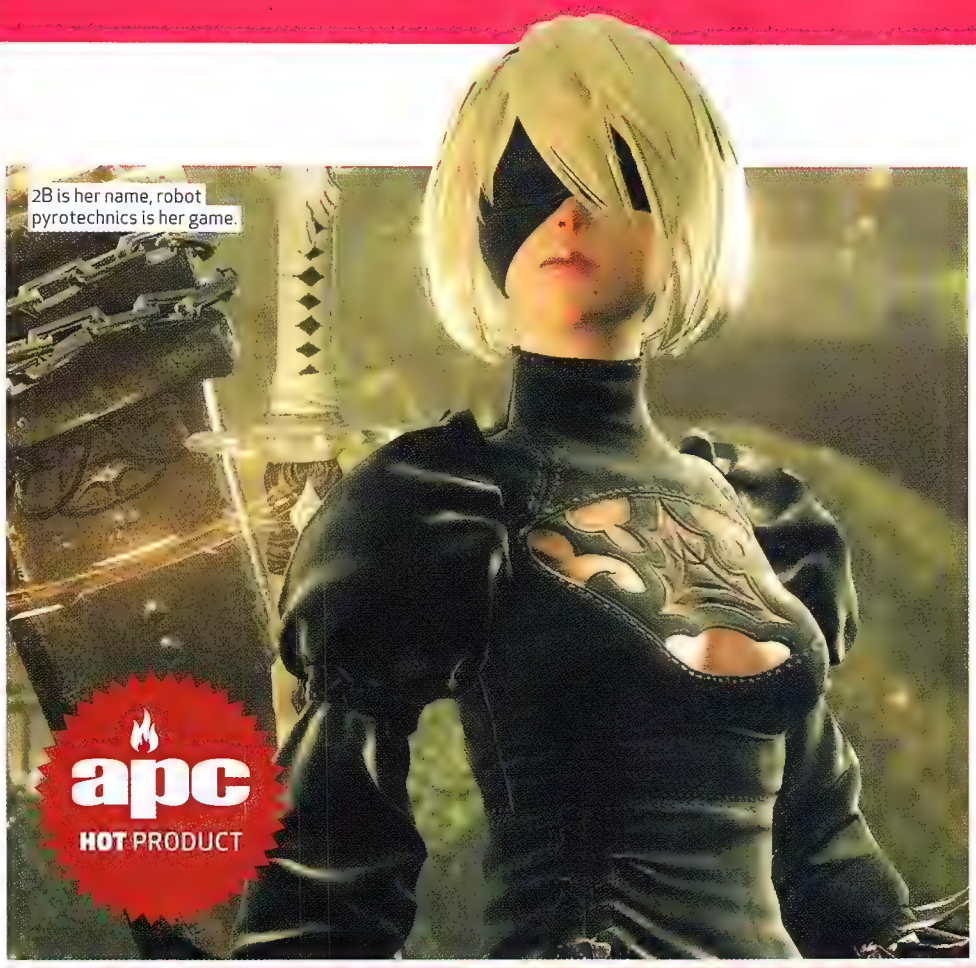
■ Dave Meikleham

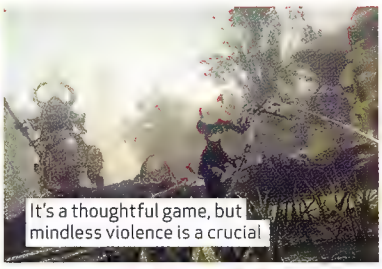
The Machines are as beautiful and varied as the game's world itself.

Verdict

The gorgeous world is a magnificently varied sandbox.

★★★★½





99.95 | PC, PS4 | WWW.NIER-AUTOMATA.COM

Nier: Automata

A surreal, unpredictable and unmissable action RPG.

In this age of games doing their utmost to resemble dramatic Hollywood blockbusters, *Nier: Automata* is an immensely gratifying breath of fresh air. If you can imagine a game with the bombastic unpredictability of a Hideo Kojima title, mixed with the self-aware melodrama of David Lynch's *Twin Peaks*, then you're about halfway towards understanding the tone of this game. Which is, by the way, a masterpiece.

You play as 2B, a highly lethal android recruited to avenge planet Earth from brutal alien colonisers. In order to do this, you've got a growing arsenal of fluid hand-to-hand weapon and melee attacks, as well as a handy floating robot which doubles as a machine gun. As most have come to expect of Platinum Games, the combat is fast and fluid, and engaging with enemies is its own reward. While the action takes place over a fairly rudimentary apocalyptic open world, *Nier: Automata* is notable for its utterly bonkers set pieces, which appear and depart as frequently and randomly as fetch-quests do in other RPGs (though to be fair, *Nier: Automata* has fetch quests, too, just not too many).

As for those set pieces, they're more than just staged instances of skyscrapers collapsing: sometimes, they deviate entirely from the main theme. The game's introduction, for example, is at once a side-scroller, a top-down bullet hell shooter and a third-person action RPG. Later, when exploring the small but functional open world, the camera will often shift to a fixed topdown view. While most open-world games promise oodles of repetitive content in the name of bang for buck, *Nier* opts instead to surprise around every corner, to offer new experiences rather than variations of the same one.

And while the game can't match most major Western games in terms of fidelity and scale, it shames all competition in terms of style and execution.

The music, composed by series mainstay Keiichi Okabe, is at once enlivening and sweetly melancholic. One of *Nier*'s early narrative beats takes place in a psychedelic carnival inhabited by both hostile and friendly helper robots, and the combination of the beautiful fairground environment and Okabe's surreal score is unforgettably strange.

2B's story is longwinded but, crucially, never boring. It's not necessarily the unpredictability of its narrative or the depth of its characters that makes *Nier*'s story so captivating. Rather, it's the cleverness of the writing and its willingness to alienate unimaginative players that makes for such an unforgettable ride.

Rarely is a major action RPG imbued with such a surreal streak, and rarely would a publisher dare push something out to a market which doesn't echo the severe and overbearingly worthy tone of games like *Horizon Zero Dawn*.

Even if you can't stomach *Nier*'s weirdness (and if so: why, you sad sack??) it's good that games as odd as this can still exist.

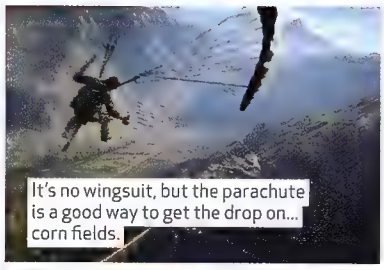
■ **Shaun Prescott**

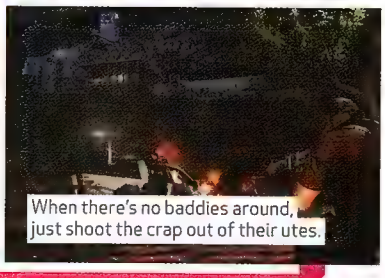
Verdict

A strange, thoughtful and rewarding action RPG — Japan's best since the Dark Souls series.

★★★★★

"Beautiful view, isn't it, boys? Now let's go blow things up down there."


It's no wingsuit, but the parachute is a good way to get the drop on... corn fields.


When there's no baddies around, just shoot the crap out of their utes.

PC, PS4, XO | $99.95 | GHOST-RECON.UBISOFT.COM

Ghost Recon: Wildlands

Severe infiltration sim goes whimsical and explode-y

There are not enough good tactical shooters in 2017, which means a new instalment in the *Ghost Recon* series should come as a welcome course. In theory, *Ghost Recon: Wildlands* has everything: a sprawling open world, a gear loot grind to keep the player moving through it, and a staggeringly tone deaf approach to any culture that isn't American. It's a B-movie writ large, except with a surplus of low-key distractions (Defend radios! Gather intel!) and the ability to stuff up quiet stealth missions with three other friends. It's a good game, yes, difficult to deny, but it's also a bit like a soup that's had virtually every half-rotten ingredient from the back of the fridge plopped into it. Yep, it's a Ubisoft open-world game.

From what we gathered from the plot, you're part of an American military enclave trying to stop Bolivian druglords from being druglords. This means, of course, blazing grunt-like through the beautiful mountainous landscape, sending drones into enemy encampments before raining hellfire from the sky or nearby hills (the game, surprisingly enough, punishes you for killing civilians). It's possible to take the quiet and tactical approach in Wildlands, and there's plenty of tools to let you do it – you can sync shots with your AI allies, you can use the aforementioned drones to mark enemies, you can call in reinforcements and all manner of other stuff – but the open world, *Just Cause*-esque nature of this instalment takes the edge off what really makes a tactical game tactical. That is, there's plenty of leeway for making good when you stuff it all up. Just run for those hills, infallible American, until the harried Bolivian druglords forget, five minutes later, that they've just had four Americans try to assassinate their leader.

> "It's a good game, yes, difficult to deny, but it's also a bit like a soup that's had virtually every half-rotten ingredient from the back of the fridge plopped into it."

It's easy to long for the more focused *Ghost Recon* games of yore, when one stupid error could lead to dismal failure, when a failed attempt at stealth couldn't just be solved by running away. But it's also important to take *Wildlands* for what it is, and what it is is a funny, goofy, lightly tactical buddy shooter. It wears the trademarked veneer of Tom Clancy severity, and if you want the stakes to feel high, then you need to suspend your disbelief (i.e. pretend you can't just run away). In typical Ubisoft fashion, there's tonnes to do, and as a shooter, it feels good enough, and missions can pan out in some hilarious and unexpected ways. It's just... why can't we have a true slow-and-steady-wins-the-race shooter for once? Why does this need to be a *Ghost Recon* game? Why can't we have a real *Ghost Recon* game? I don't know. Blame gamers.

■ Shaun Prescott

Verdict

It may be a bucket-of-content Ubisoft game, but playing tactically and with friends is a blast.

★★★½☆

Remnants of lost civilisations litter every corner of the world, representing long-forgotten cultures, races and religions.
apc
HOT PRODUCT

PC, PS3, PS4 | PS3/4, $99.95; PC, US$49.95 | WWW.BANDAINAMCOENT.COM

Torment: Tides of Numenera

Make your mark on a weird far-future world.

Centuries ago, a legendary figure called the Changing God discovered the secret to immortality. He learned how to build new bodies, far superior to normal humans, and transfer his soul into them. But when he was done with one body, he'd abandon it for another. And you play as one of these Castoffs, an empty vessel that grows a consciousness of its own and becomes... well, whoever you want them to be.

Tides of Numenera is set a billion years in the future, in a world where countless advanced civilisations have risen and fallen. Everywhere you look, there are fragments of the old world: arcane machines, statues of forgotten gods, ancient computers, and other objects. And this is where you, the youngest of the Changing God's children, find yourself.

This is a role-playing game in the truest sense. Previous Castoffs have become many things – assassins, slavers, priests, poets, even royalty – and you get to decide what path you'll take.

The Ninth World is full of opportunities, and getting tangled up in the lives of the people there leads to encounters and dangerous situations that will shape your character.

Quests are varied and unpredictable. A simple task will often spiral into something much more complex, forcing you to make tough decisions. And you never know what you'll be doing next. One minute you're hunting a serial killer, the next, you're trying to convince a race of electricity-eating monsters to stop tunnelling under a city and destroying people's homes.

The writing is superb. Some of the best we've seen in an RPG, in fact. It's rich, evocative and poetic, drawing you into its world and making you genuinely care about its characters.

At first, the sheer strangeness of the setting can be overwhelming, but you soon adjust to it. You'll form deep relationships with your companions, too. They all have fascinating backstories to discover and personality quirks that you'll grow to love or hate.

The world is governed by 'Tides' – gold, red, blue, silver and indigo – which replace the binary good/evil system seen in most RPGs. Do a good deed and the gold tide will shift. Make a tough decision for the greater good and the indigo tide will shift. And the more a particular tide shifts, the more likely it is to become your dominant one, which will determine how people regard you.

There's deep turn-based combat that will be familiar to anyone who's played games like *Pillars Of Eternity* or *Baldur's Gate*. But one of the best things about *Numenera* is how conflict can almost always be avoided. You can persuade enemies to back down, but your likelihood of succeeding depends on your stats. A silver-tongued Castoff might be able to pull this off, but one whose stats lean towards combat, magic, or technology may not.

A compelling, beautifully written story, varied quests with multiple outcomes, and a fascinatingly weird setting make *Tides of Numenera* one of the deepest, richest RPGs we've played in years.

Whichever path your Castoff takes through this world, and whatever they decide to become, you can be sure their journey will be an interesting one.

■ Andy Kelly

Verdict

Wonderful writing, deep quests, and the ability to truly shape your character... a quality RPG.

★★★★½

Blizzard blitzes *Overwatch* fan's parody Playboys

Fake fan covers fall to copyright claim.

DeviantART is a website where all manner of visual artists post their work, receive feedback, join groups and make connections. One particular artist, manusogi, decided that, rather than just draw the usual sort of fanart you find around the internet, he would create some truly amusing Playboy parody covers starring the ladies of *Overwatch*. The community soon took this idea and turned it into a whole site dedicated to horny fan art, nerdy articles and interviews with cosplayers. However, the creators of the mag were hit with a copyright claim from Blizzard, meaning only the cover images are available to view at present. Although the project was created to give "*Overwatch* fans a new way of enjoying the game," Blizzard didn't quite see it that way. Bah, humbug.

The tiny 'Beat the Boss' phone is made for easy smuggling (in your rectum)

"FREE YOUR HANDS, NO MORE TROUBLE."

Phones these days are all about big screens and easy-to-use interfaces, but some manufacturers have other goals in mind – i.e. getting phones past security screens. The Beat the Boss J8 handset is a 99.99% plastic, 6.6cm-long "Bluetooth earphone dialer phone" weighing in at just 19 grams. Possessing all the functions of a basic phone, it can also sync your contacts and music, and it apparently feels very smooth and comfortable in the hand. However, this device isn't just meant for people who dig smaller, simpler devices. No. This unassuming black phone has been designed to be smuggled past metal detectors and other security screens by being fitted into the anus, and it apparently works, too. But our most pressing question here is... does it vibrate on silent?

The fastest sketch pad in the world

...IS A TESLA.

Tapping something three times is very reminiscent of Dorothy trying to get home from Oz, but this time, it's Elon Musk's turn to do a little bit of magic. In late March, Musk went to Twitter to announce the arrival of V8.1, the latest software update to all of the company's cars. As well as the introduction of Auto Lane Change, Lane Departure Warning and Tesla Summon, plus the improvement of Autosteer, this firmware update also comes with a little cheeky Easter egg – a sketch pad. By simply tapping the 'T' button on the centre screen three times, the screen will turn itself into a digital drawing pad! While we're not entirely sure if this will have any practical uses, we're also not entirely sure we care if it doesn't! All cars should have them!

The Emoji snake

THE HAPPIEST SNAKE IN THE WORLD.

Some creatures (particularly domesticated cats and dogs) have been selectively bred to produce certain shaped faces, fur length, speed and colour. While some breeds have developed serious health issues because of this (bulldogs and persian cats, for instance), others are happily unaffected. Take this breeder's python, for instance – he is the result of eight years of selective breeding (by the pythons, not the breeder... obviously) to produce this smiley-faced-Emoji snake from a naturally occurring pattern. Apparently being worth in excess of US$5,870, this reptile has a right to be happy with himself, we think! ■

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- Dual Gigabit WAN ports with 3G/4G Load Balance and failover
- 5 x Gigabit Ethernet LAN ports with 50,000 NAT sessions
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- Object-based Firewall
- IPv6 & IPv4
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- VoIP (V model)
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Vigor2912 Series

Dual-WAN broadband router with Security Firewall and 16 x VPN tunnels including 8 x SSL-VPN tunnels

TAIWAN EXCELLENCE 2014

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- 1 x Fast Ethernet WAN port
- 1 x Selectable WAN/LAN port
- Load balancing & Failover
- 3 x Fast Ethernet LAN ports
- 30,000 NAT sessions
- Object-based SPI Firewall
- Content Security Management (CSM)
- 16 x VPN tunnels
- IPv6 & IPv4
- 1 x USB port for 3G/4G LTE mobile broadband access, USB printer and storage
- Multi subnet WAN/LAN through 802.1Q
- Comprehensive QoS features
- Works with VigorACS SI management system
- Smart Monitor Traffic Analyzer (up to 30 nodes)
- 802.11n Wi-Fi (n model)

Vigor2120 Series

Gigabit broadband router with Security Firewall and 2 x VPN tunnels including 2 x SSL-VPN tunnels

2x VPN

- 1 x Gigabit Ethernet WAN port
- 4 x Gigabit Etherent LAN ports
- 1 x USB port for 3G/4G LTE mobile broadband access, USB printer and storage
- 2 x VPN tunnels including 2 x SSL-VPN tunnels
- Comprehensive QoS features
- Object-based SPI Firewall
- Content Security Management (CSM)
- Multi subnet WAN/LAN through 802.1Q
- IPv6 & IPv4
- 2.4/5 GHz Concurrent Dual-Band Wi-Fi (n-plus model)
- Works with VigorACS SI management system

i-LAN TECHNOLOGY

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